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Basics of Geo-Mechanics and Hydrology

The geo-mechanical characteristics of the overburden and the raw material, in combination with the tectonic composition of the underground, have direct influence on the design of an open cast mine and the selection of the mining technology. The hydro-geology of the target area, in which an open cast mine is to be planned, together with geo-mechanical characteristics of the rocks, directly influences the stability of benches. The water inflow from the surrounding mountains into an open cast mine must technically be stopped, so that a smooth, secure and effective raw material extraction can be ensured. One exception is the so-called wet mining, where raw material extraction is done under the water-level.

This brief introduction already points out the fact, that capturing the rock-mechanical and hydro-geological composition of the underground is a basic pre-requisite for a technically and economically optimized open cast mine planning.

Due to the fact that deposits of mineral raw material have to be distinguished on the basis of their formation in soil and hard rocks, they display different geo-mechanical and hydrological characteristics. Following, the geo-mechanical characteristics of soil and consecutively the characteristics of hard rocks will be described.

Elementary Soil Properties

In principle, soil is not composed homogeneously, but it is composed of a solid, a fluid and a gaseous phase. The solid particles, which consist of minerals or organic material, can be found in different grain sizes (boulders, blocks, rocks, gravel, sand, silt, clay) in any mix ratio. Apart from the different grain forms, which have an influence on interactions between the grains, the charge and electrical linkage forces (repelling, pulling) are of importance, particularly in small particles. The individual components of the solid phase can furthermore be agglutinated, whereby clay or lime plays an important role. The fluid phase usually consists of water with dissolved minerals, the gaseous phase in most cases consists of air.

The portion $V_s$ describes the solid material volume (dry solids). The portion of soil volume which is not filled with solid substance (in Picture 1 is called $V_p$ and is divided into gas volume $V_g$ and liquid volume $V_f$) is defined as porosity $n$.

The porosity $n$ of soil and the void ratio $e$ have a functional connection and can be converted into each other with the following terms:

Term 1:

$$n = \frac{e}{1+e}$$

Term 2:

$$e = \frac{n}{1-n}$$

The higher the porosity of the soil, the higher is its permeability.
Grain size and grain size composition

The grain size and the composition of the grain size, respectively, determine the classification of soil. In picture 3 the grain size groups clay, silt, sand, gravel and stone, as well as upper and lower grain size limits are shown.

In order to determine the composition of grain sizes, basically two methods are used, i.e. screen analysis and hydrometer analysis.

SCREEN ANALYSIS:

One of the methods most widely used for determining particle size distribution is the screen analysis. The screen analysis is suitable for non-cohesive soil with grain sizes of 0,0063 mm to 125 mm. The soil to be examined is dried and later divided into grain size groups by mesh screens or quadratic-perforated screens. The mesh size corresponds to a standardized size grading (screen array). The grain sizes are ascertained by the nominal width of the screens, which they have last passed. Picture 4 shows the screens of a screen analysis, with mesh widths of 16 mm, 8 mm, 4 mm, 2 mm, 1 mm, 0,25 mm and 0,125 mm.

<table>
<thead>
<tr>
<th>Type</th>
<th>spectrum of grain size in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; fine grain or Clay</td>
<td>≤ 0,002</td>
</tr>
<tr>
<td>fine-</td>
<td>U &gt; 0,002 - 0,006</td>
</tr>
<tr>
<td>middle-</td>
<td>0,006 - 0,02</td>
</tr>
<tr>
<td>gross-</td>
<td>0,02 - 0,06</td>
</tr>
<tr>
<td>Sand</td>
<td>&gt; 0,06 - 2</td>
</tr>
<tr>
<td>fine-</td>
<td>S 0,06 - 0,2</td>
</tr>
<tr>
<td>middle-</td>
<td>0,2 - 0,6</td>
</tr>
<tr>
<td>gross-</td>
<td>0,6 - 2</td>
</tr>
<tr>
<td>gravel</td>
<td>&gt; 2 - 63</td>
</tr>
<tr>
<td>fine-</td>
<td>G 2 - 63</td>
</tr>
<tr>
<td>middle-</td>
<td>6,3 - 20</td>
</tr>
<tr>
<td>gross-</td>
<td>20 - 63</td>
</tr>
<tr>
<td>Stone</td>
<td>X &gt; 63</td>
</tr>
</tbody>
</table>
Pic. 4: screen analysis [7]
HYDROMETER ANALYSIS

The hydrometer analysis is suitable for cohesive soil (d < 0.125 mm). In this analysis, the soil sample is mixed with water to form a suspension and poured into a level gauge. The method is based on the physical property that grains of various sizes sink with different velocities in standing water.

The distribution of the grain sizes and as such the density in the suspension changes with the different velocities of sinking of the grains. The grain size distribution is determined through suspension density with the aerometer method, which determines the weight portion of the respective grain fraction. This is done through immersing the aerometer into the suspension in defined time intervals and reading the immersion depth, which is dependant on the density. Based on the immersion depth in the defined times, the density and the mass fraction of the various grain groups can be read from a nomogram.

Picture 5 shows an areometer, which is used for the hydrometer analysis.

Pic. 5: Areometer for the hydrometer analysis [7]
In the interpretation of the screen analysis, the respective portion of screenings is calculated by the total dry matter and converted to the respective screenings. In hydrometer analysis the proportion of weight of the respective grain fraction can directly be determined by the suspension density. The cumulative frequency polygon of the mass fraction is called grading curve. The grading curve is a cumulative frequency polygon, so it is not a distribution in the mathematical sense, although the name “grain size distribution” is often applied in common language use. The demonstration is done in a semi-logarithmic scale. In picture 6 the grading curves of various soils is shown.

The steeper a grading curve is, the more homogeneous the soil is. The flatter a grading curve is, the more inhomogeneous the soil is. The blue grading curve of the boulder clay shown in picture 6 describes such an inhomogeneous soil. It consists of particles with grain sizes of approx. 10 mm to smaller than 0,001 mm. If any point is chosen on a grading curve and a parallel line is drawn to the x-coordinate and the ordinate (the red line in picture 7), then the intersection of the horizontal line with the ordinate describes the portion that is smaller than the grain size, which is characterized by the intersection of the vertical line with the x-coordinate. In the shown example of boulder clay, 70% of the grains are smaller than 0.4 mm. With the same system it can be determined that in the same material 30% of the grains are smaller than 0.02 mm (light blue lines).

The inclination of the grading curve indicates the homogeneity and inhomogeneity of the soil, respectively. This is of importance for various soil characteristics, such as for example for the compactibility of soil. In terms of numbers the homogeneity and inhomogeneity can be expressed through the coefficient of uniformity U.

Term 3:

\[ U = \frac{d_{60}}{d_{10}} \]

Hereby \( d_{60} \) and \( d_{10} \) are the grain sizes in mm, with which the cumulative curve intersects the 60%- and the 10%-line respectively. In picture 8 the determination of \( d_{60} \)- and \( d_{10} \)-values of the boulder clay are demonstrated as examples.

Pic. 6: Grading curves [6]
Pic. 7: Interpretation of grading curves

Pic. 8: Determination of the coefficient of uniformity $U$, example A
In this case the d60-value lies with a grain size of 0.2 mm. The d10-value is 0.002 mm. According to the above-mentioned formula the coefficient of uniformity U can be calculated as 100. The values listed in Table 1 show the limits for the distinction between a homogeneous and a very in-homogeneous soil. Based on the source used these values fluctuate slightly. The boulder clay reviewed in this example clearly lies in the very in-homogeneous area.

Apart from the coefficient of uniformity U, the curvature coefficient c is another reference number to be defined. The Kz characterizes the course of the grading curve between the d10 and d60 range of grain sizes and is described by the following term:

Term 4:

\[ C_c = \frac{d_6^2}{d_1 \cdot d_6} \]

Essential soil characteristics like for example the aggregation of non-cohesive soil can be derived from the curvature coefficient c and the coefficient of uniformity U.

**Grain form**

The grain form is dependant on the crystalline isotropy of the grain mineral and on the transport distance before sedimentation. The crystalline isotropy of the grain mineral describes an almost constant mineral stability in all directions. If this criterion is fulfilled at the time of the formation of the rock, cubical or spherical grain forms, which for example are typical for quartz sand, are generated in the final form. If, on the other hand, the rock has anisotropic mineral stability, laminated rocks are generated. Based on crystalline isotropy, distinction is made between spherical, compact, prismatic, laminar, rod shaped and flaky particles.

Apart from the composition of the elementary rock, the transport distance is of importance. During their transport route to the location of sedimentation, the rock particles are transported through water, air or ice and are further broken. As such, grains are broken by flowing water, for example, according to the principle of a pebble mill and are polished. The longer the transport distance is and the higher the kinetic energies act on the rock particles, the smoother and more even the grain surface is. Picture 9 shows the change of grain form in longer lasting transports.

The grain form is associated with grain roughness, together both characteristics determine the mechanical behaviour of the grains in mutual movement.

**Grain density and grain weight**

The expression grain density is defined in DIN 18124 (foundation, Examination of soil samples – determining grain density). According to that, the grain density \( \rho_s \) of soil is the mass of the solid components \( m_d \), with reference to the volume \( V_K \) of the components, including the hollows that are not moistened by the measurement liquid [11].

The unit of the grain density is g/cm³ or t/m³ and can be calculated according to the following term:

Term 5:

\[ \rho_s \left[ \frac{g}{m^3} \right] = \frac{m_d \left[ g \right]}{V_K \left[ m^3 \right]} \]

Table 1:

<table>
<thead>
<tr>
<th>DIN 1054 (4.2.1)</th>
<th>Soil engineering book (1980)</th>
</tr>
</thead>
<tbody>
<tr>
<td>uniform ( U &lt; 3 )</td>
<td>( U &lt; 5 )</td>
</tr>
<tr>
<td>non-uniform ( U = 3 - 15 )</td>
<td>( U = 5 - 15 )</td>
</tr>
<tr>
<td>high non-uniform ( U &gt; 15 )</td>
<td>( U &gt; 15 )</td>
</tr>
</tbody>
</table>

Apart from the composition of the elementary rock, the transport distance is of importance. During their transport route to the location of sedimentation, the rock particles are transported through water, air or ice and are further broken. As such, grains are broken by flowing water, for example, according to the principle of a pebble mill and are polished. The longer the transport distance is and the higher the kinetic energies act on the rock particles, the smoother and more even the grain surface is. Picture 9 shows the change of grain form in longer lasting transports.

The grain form is associated with grain roughness, together both characteristics determine the mechanical behaviour of the grains in mutual movement.

**Pic. 9:**

Demonstration of various grain forms [10]
Hereby the dry solids \( m_d \) are determined after drying of the soil sample at 105 °C. The grain volume is determined by a Capillarpyknometer. The measurement method of the Capillarpyknometer is to determine the volume of the solid with the help of the added water volume. The pyknometer consists of a volumetric flask with a filling volume that can exactly be ascertained. The grain volume can be calculated from the weight of the pyknometer which is to be filled, the water-filled pyknometer, and the pyknometer filled with water and a measured sample amount of dried and crushed soil.

The grain weight \( \gamma_s \) of soil describes the weight \( G \) (kN/m\(^3\)), depending on the volume \( V_k \). The grain weight can be calculated from the grain density with the following term:

\[
\gamma_s = 1,0 \cdot \gamma_s \left[ \frac{N}{m^3} \right] = 9,8 \cdot \rho_s \left[ \frac{g}{m^3} \right] \cdot \text{bzw.} \cdot \frac{t}{m^3}
\]

In practical calculations the gravitational acceleration \( g \) can approximatively be set at a value of 10. This results in:

\[
\gamma_s \left[ \frac{N}{m^3} \right] \approx 0 \cdot \rho_s \left[ \frac{g}{m^3} \right] \cdot \text{bzw.} \cdot \frac{t}{m^3}
\]

The grain density \( \rho_s \) and grain weight \( \gamma_s \), respectively, serve as an auxiliary value to determine the porosity, the water content through immersion weighing and the grain size composition of a soil sample through sedimentation analysis.

In case of soil density and weight, (in contrast to grain density and weight) the volume \( V \) is the entire volumes of the solid substance, the pore fluid and the pore air.

In the following table 2 typical grain densities, grain weights, as well as other parameters of non-cohesive and cohesive soils are gathered.

**Table 2:**

Weights and densities of various soil groups

<table>
<thead>
<tr>
<th>Type of soil</th>
<th>Grain density ( \rho_s ) [g/cm(^3)]</th>
<th>Grain weight ( \gamma_s ) [kN/m(^3)]</th>
<th>Dry-weight ( \gamma_D ) [kN/m(^3)]</th>
<th>Weight of wet soil ( \gamma_I ) [kN/m(^3)]</th>
<th>Water content of waterlogged soil ( \gamma_I ) [kN/m(^3)]</th>
<th>Weight of soil by uplift ( \gamma_I ) [kN/m(^3)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>high cohesive soil</td>
<td>2,7 - 2,75</td>
<td>27,0 - 27,5</td>
<td>11,0 - 17,0</td>
<td>16,0 - 20,0</td>
<td>17,0 - 21,0</td>
<td>7,0 - 9,0</td>
</tr>
<tr>
<td>low cohesive soil</td>
<td>2,67</td>
<td>26,7</td>
<td>16,0 - 21,0</td>
<td>19,0 - 22,0</td>
<td>20,0 - 23,0</td>
<td>9,0 - 11,0</td>
</tr>
<tr>
<td>non cohesive soil</td>
<td>2,65</td>
<td>26,5</td>
<td>15,0 - 18,0</td>
<td>16,0 - 20,0</td>
<td>19,0 - 22,0</td>
<td>10,0 - 11,0</td>
</tr>
</tbody>
</table>
Bibliography

[5] Rheinbraun AG Informationsbroschüren
[6] Prinz Abriss der Ingenieurgeologie
[10] Schultze / Muhs Bodenuntersuchungen für Ingenieurbauten, 1967

Univ.-Prof. Dr.-Ing. habil. Hossein H. Tudehski studied from 1977 to 1980 at the Mining College of Shahrud (Iran); following several years of work in the mining industry, he completed his mining study at the RWTH Aachen in 1989. Since 1992 he was Chief Engineer at the Institute for Surface Mining (Bergbaukunde III) of the RWTH Aachen, mainly active in the field of open cast mining and drilling technique. He did his doctor degree in 1993 and qualified as a university lecture in 1997. In 1998 the Venia Legendi was awarded to him be the RWTH Aachen for the field “Rock and Earth Open Pit Mining”. In November 2001 he was appointed as Professor for Surface Mining and International Mining at Clausthal University of Technology.

He already has over 25 years of experience in the field of project planning and cost-benefit analysis within the frame of various mine planning projects. The international tasks rendered by him mount up to more than 300 international raw material-related projects.

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The machine has been designed to ablate all kinds of rocks, gypsum, coal and other material (e.g. concrete). This is done using a big, hydrostatically steered milling drum, which ablates the rock in a more efficient way and with a higher cutting depth.

The result:
More coarse material with a low proportion of fine fraction.
Development and Planning of a Quarry Location with Initial Mine Development and High-quality Chipping Plant in the Ukraine

During the past years companies have increasingly been investing in East Europe, in order to benefit from the chances of markets with increased demand. In addition to existing operations, greenfield projects are also increasingly being developed. A multitude of questions and investigations, which exceed the extent of investigations in-country projects, have to be answered in the decision and planning phase. Usually the opening up of East-European countries is joined with a legal and social structural change, so that in parts the legal security, market knowledge and binding public plannings are missing.

In the current document some aspects of this set of problems is discussed at the example of development and planning of a quarry location with initial mine development and high quality chipping plant in the Ukraine.

Initial Situation and Procedure

Due to the changes in the political system, as well with regard to the planned renewals and expansions of the entire infrastructure in the Ukraine and the bordering states, there is a high demand for construction material, particularly for rubble, chippings and sands. Despite the consequences of the international financial crisis, which led to a transient break-in of the construction sector, a medium to long-term increased demand is expected, due to the regional-geological circumstances, a high basic demand and a multitude of infrastructural projects (e.g. European Football Championship, 2010, Olympic Winter games 2014 in Scotchi, highways, railroad networks).

In the public sector various investment programmes are under way, particularly under the aspect of industrial core areas and due to the transit character of the Ukraine. These projects are partly funded by international finance institutions like the EBRD and the World Bank. Commissioned by a German investor group that is planning to use the chances arising from the above-mentioned situation, a suitable location for production of construction material with a granite deposit near Korosten, Zhytomir region of the Ukraine was developed, as per picture 1. In particular, a high-performance open cast mining and processing operation, along with the required infrastructure has been planned. The various possible options of project development and marketing, based on local conditions are discussed in the current document.

Pic. 1: General map showing the position of the location to be developed
Basics of Market Review and Required Range of Products

The products of the quarry operations are either used directly or as aggregates for concrete and asphalt in civil engineering above ground (e.g. buildings, bridges), below ground (e.g. roads), track construction (e.g. roadbed, slab tracks), hydraulic construction (e.g. shoreline stabilization) and other construction areas (e.g. filler, fertilizer). They are subject to extensive quality control with fundamental aptitude testing and a multi-level control system of surveillance in in-house laboratories and certified outside institutes. In order to be used in the public sector, an authorization of the respective regional government authority is necessary. Apart from locally used grain sizes, rock-specific characteristics like for example hardness, polished stone value and frost resistance are of vital importance. Natural stone products are bulk goods with high freight costs, the distribution range of which is limited by the means of transport and the competitive environment. Particularly in the Ukraine and in Russia, raw materials are transported for up to 1,000 km, depending on the available deposits and the regional geology. The need for raw material is, among others, dependant on the population, the transport infrastructure (new construction, maintenance, development tendencies), the public spending behaviour, and further financing forms (e.g. PPP projects). In the cross-border transport, different country-specific standards and classifications of grain fractions might have to be considered.

Country-specific product groups that are being manufactured are:

for Poland
- Gryz (Chippings): 2/5 mm, 5/8 mm, 8/11 mm, 11/16 mm, 2/8 mm, 8/16 mm, 16/25 mm
- Tluczen (Rubble): 31,5/63 mm
- Miezcenka (Mixedtured): 0/31,4 mm, 0/45 mm, 0/63 mm
- Amourstone: 80/150 mm, 150/450 mm

for Ukraine und Russia
- Sand 0/5 mm
- Chippings 5/10 mm, 5/20 mm, 20/40 mm, 40 – 70 mm
- others

It is for this reason that the materials preparation technology needs to be set according to target markets.

Selected Criteria for the Examination and Information Requirements at the Location and for the Deposit

Apart from the legislative regulations, the actual features and characteristics, as well as the state (quality) of the location factors are decisive. The location factors include the geo-genic prevailing deposit, particularly the direct environment with spatial planning and actual specific land-use, the local supply and transport infrastructure, as well as the qualitative and quantitative labor potential and offer. Each location planning must carefully be prepared and examined, in order to achieve highest possible safety in planning, operation and investment. The general requirements to be investigated are outlined in the following chapter:
The location near the small town of Korosten has the following characteristics, which need to be taken into consideration in planning:

- **Locality:** The location lies in the West Ukraine in Oblast Zhytomyr, near the small town of Korosten, approximately 180 km west of Kiev.

- **Local public infrastructure/transport infrastructure:** The site lies in the outskirt area and has a connection to paved local roads and the nationwide long-distance transport road network. There is a railway loading possibility in the radius of 3 km.

- **Planning law:** This is a mining area with Ukrainian mining law. A so-called pre-license for geological exploration is necessary for the exploration, and for the consequent mining a main license, corresponding to an authorization, is needed.

- **Topographic shape:** The area is a typical plain landscape.

- **Utilization:** The site currently encompasses approximately 140 ha and has partly been used as factory area, quarry and embark point. The operation was stopped after the breakdown of the Soviet Union in 1991/1993, since no employer took responsibility and the staff was not paid, which is typical for the country. The newly cast mine which is to be developed with infrastructure and processing plans will be opened approximately 2 km from the factory area on “green fields”. These areas are currently being used for forestry and agriculture.

- **Environment and Brownfields:** Following local inspection, no suspicious areas were detected. The future open cast mine area has a sandy base, which has been used as driving school drill ground for chain vehicles. Based on additional local investigations, ammunition or other contaminations are not to be expected. Following the researches, no environmental risks, archaeological sites or nature protection areas. The nearest Immision location (built-over areas) are in a distance of approximately 2,000 m. This is a considerable distance, since the required minimum distance in the Ukraine is 500 m from the designated village area.

- **Land/properties:** The land is owned by the state and is leased for 49 years, as it is mostly the case in the Ukraine. An expansion of the areas is easily possible. A purchase option should be negotiated for the case of privatization.

- **Deposit:** The deposit consists of granite, which is a utility. A geological exploration with a sufficient number of core drillings has been recently conducted on a partial area of 44 ha. Representative samples were also examined by a certified institute in Germany. According to local and EU-standards, the rocks can be used in building construction, civil engineering, track and road construction. The proven mineable deposits in this partial area are a minimum of 61,900,000 t, with an overburden of 2,045,000 m³. This results in favorable overburden conditions, in case of a mining of 1,5 Mio t/a a lifetime of 41 years. The possibility of expanding the area and depth is also given.

- **Quarry type:** The mine development form to be considered is a typical “Kesselbruch”(counterbore field) i.e. mining in depth. The relation of overburden to exploitable mineral is a minimum of 1:30, 5 and is economically very cost-effective. Based on hydro geological explorations and local researches, there is not danger of unplanned water inflow, groundwater or flooding.

- **Special features:** In case of appropriate mining process selection, no atypical or special risks are expected from the technical and economical point of view.

- **Suitability of material:** Following appropriate processing, the existing rocks are unrestrictedly suitable for the production of mineral mixes, simple chippings for asphalt and concrete according to EU standards (export to Poland). According to valid Ukrainian norms the material is suitable for all construction and application areas.

### Requirement profile for Planning the Location and Plant

Apart from a suitable deposit, the basis of the construction material production is an open cast mine (quarry), a downstream processing plant, as well as the required supply and transport infrastructure.

As a basis for the local planning of location, the required and targeted production capacity was set with special consideration of the following points.

- **Sustainability and Fluctuations in the Demand of the Target Markets:** The sustainable and long-term demand of the planned target markets can be subject to extreme fluctuations, particularly in the observed regions with accumulated needs. This is due to the fact that the market is first overheated and available production capacities are too little or too old. Following a distinct boom phase, which often leads to increase in capacity, usually a stable market slump occurs, which leads to considerable amount and price collapses. An example is the situation of the past 20 years in East Germany.

- **Demand for Products and Product Ranges with Different Standards:** As outlined above, the planned location in the Ukraine will supply not only the in-country market, but also the Russian and polish market, which considerably differ in standard grainings and construction methods.
The goals are basically realized through the following organizational measures:

- **Open cast mine:** Optimizing the direction of mine development, development of deepest bench, introduction of several prepared pits for quality control, optimum handling of overburden and road construction

- **Processing:** Optimization, objectification and equalization of the entire sequence and production control, automation and optimization of capacity utilization of key equipment, introduction of a process automation system, avoiding design flaws

- **Quality control:** Optimization of quality control systems, active control in open cast mining and processing plants, reducing reaction times in disturbances, appropriate documentation in the plant and on the construction site

- **Maintenance:** Introduction of a preventive maintenance and repair system, design changes in flaws, optimization of warehousing, continuous examination and, if necessary, improvement of quality, methods and cost structure in the spare-part and supply sector, reduction of reaction and implementation times in procedural and machine disturbances

- **Controlling:** Suitable and sensitive reporting, benchmarking, introduction of fully developed control systems

- **Organisation:** Relocation of production- and maintenance times, production in day shifts 1, 1.5 or 2 and scheduled maintenance with a small team in the 2nd shift or night shift reduce unproductive times (overlaps in breaks, optimization of changes in shifts, start-up and shut-down of technical equipment, etc.), reduction of winter repair times

- **Personnel:** Working with permanent staff, including administration and management, training and qualifying of personnel

- **Leadership:** Creation of an effective organization and leadership structure with exact definition of responsibilities, areas of responsibilities and assignments

From the technical point of view the used machines and plants were designed based on the following requirements:

- **Dimensioning and endurance strength** are chosen appropriately, since they significantly determine the factors performance characteristics (power reserves), economical service life, as well as the residual value of the equipment.

- **Standardized and typecasts components,** as well as a modular design with easy accessibility of the components achieves ease of maintenance and repair.
A high operational availability is achieved through optimizing the internal factors of production organization, minimizing the needed set-up and unproductive times (e.g. for relocation or blasting), as well as constructive factors like for example long maintenance intervals with short maintenance times.

Furthermore external cost –determining factors like e.g. short-term availability of spare parts and mechanics, as well as the possible need for special tools (e.g. hydraulic presses, motor testers, etc.) are considered in the calls for bids.

Optimum consumption data of the machines, the secured possibility of using low-cost raw material, additives and lubricants, as well as energy carriers, the usage of standardized and universally available spare and wear parts are considered as main aspects for an economical operation.

User-friendly diagnosis and control systems, as well as an appropriate automation serve as data basis and instruments for exact control, invoicing and target/ performance comparison.

The intersections between partial systems are designed in a way that the different operating characteristics (e.g. continuous and discontinuous), capacities, as well as amounts or sizes of material streams do not lead to disturbances in parts or in the entire system. Appropriately dimensioned buffer units were applied for decoupling in case of very different characteristics.

Planning Data and Steps

The conducted market analyses and evaluations of economic efficiency were discussed intensely with investors and translated into a corporate investment concept. The aspired market volume is 1,500,000 t/year in the target regions Ukraine, East Poland, West Russia. The planned amount is to be produced in two shifts, so that timely adjustments can be made to react to additional or lower demand. Considering the local climate data, it is expected that without weekend works, there are 200 assured production days. The basic technical parameters are summarized in the following picture.

The implementation of the observations with regard to planning, which have been discussed for far, as well as the outlined criteria with regard to the need of investigations and requirement criteria calls for a multitude of steps. The basic tasks and steps are made clear in picture 3.

Selected Aspects of the Conducted Open Cast Mine Planning

In the following chapter, selected aspects of the open cast mine planning, which have formed the basis of the required specific call for bids for the purchase of equipment, services and plants, are discussed.

Selection of Mine Development and the Initial Mine

The deliberations on planning, which are partly presented here, are based on the location, as well as the geometry of the licensed authorized field. Picture 4 shows the boundary lines, position of the exploratory drillings, as well as the distribution of the iso-lines of overburden. The top ground surface lies at a level between 170 m and 182 sea level. The maximum mining depth is currently limited by approvals to the level > 86 m above sea level. Therefore under an overburden thickness of 3 to 12 m, there is a minimum of 84 m of mineable rocks. According to Ukrainian regulations, the maximum bench distance cannot exceed 14 m.

Active Benches have to be planned at 75° to 80° and end-benches at 55°. Taking into consideration these basic parameters an exploitation over several benches is planned, where 6 benches are for exploitation of raw material and one bench is for overburden.

The location of the processing plant, as well as the required stocks is placed at the south-western border, outside the authorized field, since it has the shortest distance to the road, 200m. Furthermore the authorized field tapers out in the western part, with overburden thickness of more than 9 m. The initial mine is located in the area of drilling 2, with a low overburden. In order to quickly produce quality muck, the initial mine is planned with two benches, with a bench high of 14 m each. While the first bench might still have weathered material, high quality material can be expected in the 2nd bench.

The first phase of the mining development to approximately 3 ha is implemented with sub-contractors with mobile processing plants, as well as with dumper operation. The incoming waste material is mainly used as filling material and the rocks of the first bench are processed and marketed as aggregates.
Planungsgrößen / planning parameters

| Aufgabematerial / feed material            | Granit                        |
| Aufgabekörnung / feed size                | mm 0 - 1000                  |
| Produktion Auslegungsgröße / production mass | t/ a 1.500.000         |
| Produktionstage pro Jahr (Mo. - Fr.) / production days per year | d/a 200                   |
| Produktionsstunden / Tag (Mo. - Fr.) / production hours per day | h/d 16                     |
| Produktionsstunden pro Jahr (effektiv) / production hours per year | h/a 3200                  |
| Produktionsmenge pro Tag (effektiv) / production mass per day | t/d 7.500                 |
| Produktionsmenge pro Stunde (effektiv) / production mass per hour | t/h 469                   |
| Verfügbarkeitsfaktor / availability factor | % 85                        |
| Maschinenauslegung t/d / h/d / 0,85 / machine feed rate | t/h 550                    |
| Anlagenleistung - Primärbrechstufe / plant feed rate primary | t/h 650                    |
| Anlagenleistung - Sekundärbrechstufe / plant feed rate secondary | t/h 550 + Kreislauf (circuit) |
| Anlagenleistung - Feinsplitte / feed rate fine material | t/h ca. 300                |
| Lagerkapazität pro Einzelkörnung / stock capacity per product (activ) | t ca. 1000                |
| Vorbrechanlage / primary chrusher        | Mobilgerät / mobil chrusher  |
| Transport VB-Anlage zur Aufbereitung / transport to plant | Bandanlage / belt conveyor |
| LKW - Verladung / truck loading          | % 10                        |
| Bahn - Verladung / train loading         | % 90                        |
In the second operation phase the normal operation starts on 2 benches with the expansion of the open cast mine in the southern and northern direction, while the main mining direction is to the west. The overburden is then disposed annually to the required extent, and heaped up as anti-noise barrier or transported to an outside dump. Picture 5 visualizes the planning concept of the development phase with choice of location.

Since handling of explosives currently underlies special regulations, the loosening process is done by large-diameter borehole blastings through sub-contractors. In order to minimize intersection problems, the drilling is also subcontracted to the blasting company. The geological conditions and geometrical dimensions of the deposit allow for applying a mobile primary crusher system with downstream belt conveyors. There is no need for special measures of primary screen separation, due to the existing qualities at the primary crusher, but it is foreseen for
possible fault zones. The reference point of conveyance for this operation phase is the 2nd extraction bench, i.e. the primary crusher unit is positioned here and is fed with a backhoe. With this system relocations between benches should be minimized, due to the required extra work involved, therefore so-called group extracting method is applied. Hereby the berm width between the 1st and 2nd bench is minimized to 3 to 5 m and the blastings are planned in a way that the main portion of the muck directly falls on the 2nd bench and is loaded there.

The intermediary berm divides the bench in two sections of 14 m each and leads to increased stability. The permanent ramp system with the access road to the open cast mine and conveyor belt will be established in the northern part.

The stockpile with pre-crushed material of 0 mm to 300 mm and approx. 10,000 t active volume is foreseen outside the open cast mine, in order to decouple mining and processing.

**System Selection of Mining and Mobile Equipment**

Typically the following equipment is needed for an operation with the above-mentioned parameters in the extraction area:

- **Loading equipment:** Dredger, wheel loaders and possibly Loading-crawler are applied in hard rocks. The applied dredgers can be layed out as backhoe or dipper version and are available on the market as well-engineered systems in all current sizes. Apart from the high breaking off forces with a muck that is interlocked, Here the characteristic is the easy possibility of secondary crushing of boulders through usage of a steel ball. Although mobility is given, it is disadvantageous to often change the locations of application on various benches without transport equipment, since the cruising speed is low and wear at the crawler track is high. Wheel loaders are considerably more mobile and can be installed much quicker to changing loading locations, but they have the disadvantage that the entire machine weight has to be moved in loading. Due to the shovel width high mechanical strains and wear occur in interlocked muck or in case of unevenness of the bench.

In small-sized excavated material the wheel loader has a greater flexibility than the dredger. It is also possible to boulder with balls, but this requires slightly more experience of the machine operator. Loading-crawler are only applied in exceptional cases and will not be discussed further in this article. Basically the equipment sizes have to be dimensioned in a way that the required loading and bouldering performance is achieved and the shovel size is adapted to the transport/supply unit and grain size of muck. In practice 4 to 6 loadings have proven to be optimal. In connection with the planned primary crusher system and the required extraction performance of approximately 650 t/h, a hydraulic dredger with backhoe equipment in the 80 to 100 ton category.

- **Mobile Primary Crusher Unit:** Usually the mobile primary crusher units of the operation are equipped with own crawler-typed undercarriages. There is a multitude of proven system solutions from different manufacturers and
System Planning of the Processing Plant

The processing plant processes the pre-crushed rocks to marketable products. The processing is mainly based on multi-stage grading and crushing processes. The needed technical systems can be conducted mobile or stationary. Stationary plants need a higher capital expenditure, but offer more space for storage capacity and more functional constructions. In the current case the decision was made for an open quasi-stationary plant with single crusher- and precious grit treatment. Since apart from the Ukrainian and Russian market, Poland should also be supplied according to EU norms, the single crusher treatment is adjusted to the production of local norms and the precious grit treatment is adjusted to EU standard products.

In picture 6 the process design, that was developed for the location, is presented in detail.

The mobile primary crusher system described above feeds the stockpile through conveyor belts with approx. 550 t/h of pre-crushed rocks of a size between 0 and 300 mm. With 10,000 tons, the active buffer volume is slightly more than a 2 shift daily production, and sufficiently decouples extraction and processing. The 1st secondary crusher is dimensioned as cone crusher with approx. 608 t/h throughput. Grain sizes of > 70 mm are fed to this crusher in a closed circuit with approx. 55 t/h. In order to actively influence the production and grading of the Ukrainian standard grainings, a further cone crusher is envisaged for possible consecutive crushing of grainings of 40 mm to 70 mm. In case needed, the 5 – 20 mm and 20 to 40 mm grainings are fed to the cutting crushers directly through a buffer silo, or they are stored as final granulation for selling in boxes with deducted subsurface. Since the maximum feeding size of grainings lies at < 40 mm bis 50 mm, separate consecutive crushing of the grainings 40 mm to 70 mm is required. Apart from the sand 0 = 2 mm, the cuttings which are produced with a capacity of approx. 300 t/h, are stored in open boxes with deducted subsurface. Grainings of > 20 mm can be additional gritting in a closed circuit. The boxes of finished material allow for overburden thicknesses of 13 m, with which a total quantity of approx. 3,200 t per box at approx. 1,000 t calculated with deducted subsurface amount as an asset. Picture 7 shows the layout of the overall plant. In order to optimize loading on trucks and trains, all boxes of finished product were arranged in one line about a tunnel with deducted subsurfaces.

• Transport system: In the present combination, a continuous, i.e a conveyor belt is most suitable as a transport system. The advantages of a conveyor belt are above all the cost-efficient, continuous transport over long distances with low maintenance costs. Since the material is already pre-crushed and as such the size range of the goods to be transported is determined, the dimensioning can be done with high certainty. Ascending and descending slopes do not pose particular difficulties, and in the main gates level differences due to special configurations are possible, so that costly ramp systems with possible deposit losses can be minimized. In the conveying path two basic areas need to be differentiated. While the main conveying path should remain at the same location for a longer time, suitable and short conveyor roads need to be added. These roads should be mobile in their direct connection and to be changed with little effort. Therefore particular emphasis should be given to a flexible connection of the primary crusher to the continuous conveyor. Corresponding system solutions are offered in the market.

• Reclaiming: Special equipment is needed for stockpiling and loading on trucks or trains. In order to so, wheel loaders that are offered in various sizes are suitable. For the existing location 3 wheel loaders of the 5,5 m³ category with a loading capacity of 400 t/h each are required. 2 of the equipment take care of the reclaiming, as well as stockpiling work of the finished products, if necessary. One device is foreseen as auxiliary device for loading on trains.

various combinations of screening and crushing aggregates with corresponding adjustment options for the typical site dimensions of the reviewed hard rock ranges. Variability with regard to the required processing techniques is assured. In laminar mining, mobile primary crusher units can flexibly and securely be applied over several benches, up to an entire height of approximately 30 m, in so-called group-mining. The operation mode can be both mobile and quasi stationary. The mobile operation mode is characterized by the fact that the location of the primary crusher and the loading equipment can be changed at any time, whereas in the quasi-stationary operation the location of the unit is only changed in certain intervals. The changes which result from the mining progress are bridged through a wheel loader, mostly in the land and carry operation mode. In the current case a track-mounted primary crusher system with connected lock-link system is chosen.
Pic. 6: Treatment diagram of processing in the Ukraine
Summary

This article explains selected aspects of the development and planning of a location of an open cast mine with initial mine development and chipping plant in the Ukraine. The special and significantly higher demands in planning and implementation of foreign investments result from the local legal and cultural conditions, as well as from the usually active change in structure. Old standards, laws and planning standards under public law are often only partly valid and in transition phases, whereas there is a lack of practical experience and interpretation for new standards.

The fact that the supply and business markets change dynamically makes the situation more difficult. In summary this means increased uncertainty and calls for flexible action alternatives in connection with an effective risk management. A comprehensive planning, which takes into consideration all listed basic criteria and corporate action alternatives is indispensable for foreign investment.

Bibliography

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- proseselecting of mineral raw material
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- Company conversion, location development and location adaptation of mining and building material companies, in particular in former GUS states
- Technical plannings of mine arrangements, opencast mining arrangements and processing arrangements

[18] Strzodka, Klaus, Sajkiewicz, Jan, Dunikowski, Andrzej (1979): Tagebautechnik Band I bis III, VEB Deutscher Verlag für Grundstoffindustrie, Leipzig
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- Market expansion into the mining sector of the nonmetallic minerals industry.

In the past Thyssen Schachtbau GmbH has primarily been involved in national projects for the coal, salt and ore mining industries. For the last six years the Shaftsinking and Drilling division has also been engaged in specialist engineering projects for tunnelling and hydro power plant construction industry in Switzerland.


**Excavation of a spiral chute and other development work in the Gehren barites mine**

The former fluorite and barytes mine at Ilmenau-Gehren had to be closed for economic reasons in 1991. The mine workings were subsequently flooded.

The ever growing demand for raw materials and the resulting increase in the price of imported commodities at the beginning of this century, combined with the unusual purity of the Gehren deposits, led the Fluorchemie Group to consider freeing itself from economic and political uncertainty by procuring raw-materials supplies from own resources.
Between January 2005 and mid-2006 the FSB Gehren joint venture group, comprising Schachtbau Nordhausen GmbH, TS Bau GmbH and Thyssen Schachtbau GmbH, was contracted by the Phönix Fluorite and Barytes Mine in Gehren (a subsidiary of the Fluorchemie Group) to construct an access ramp and spiral chute, and complete some 800 m of underground drivages, with a view to developing the ore body.

Before the work started it had been planned and predicted that about 70 % of the developments could be driven without support. When the heading work commenced, however, it was found that the fracture-tectonic origins of the hydrothermal lode deposits and the influence of former mine workings had combined to create an unexpected set of strata conditions.

The FSB joint venture then reacted appropriately by introducing suitable support technology and immediately modifying the drivage concept.

After that the twin-arm drill jumbo with its hole-charging cradle was able to work its way forward pull by pull. The debris was cleared out by loader and dumper – with rockbolts and shotcrete providing overhead protection.

The somewhat complex strata support arrangements consisted of seven different types of system. Systematic rockbolting with shotcrete had to be employed in various forms over practically the entire length of the drivage. Swellex bolts were installed with great success over a wide area, while the project also perfected the manipulator system for wet spraying in confined spaces.

Though exploratory work initially proved disappointing, the predicted deposits were soon proven in all four runs. The load was between 6 and 8 m in thickness and had a fluorspar content of between 30 and 50 %. Planning work was started on a new mineral preparation plant and the first items of equipment have already been delivered. Unfortunately the unexpected slump in prices and the fall in demand to practically zero caused the whole project to be suspended in May 2009. A skeleton crew has been retained to keep the mine open and the project is now awaiting the recovery of the raw-materials market.

Development work for the underground lime mine at Mähringer Berg

Märker Kalk GmbH is part of the Harburg (Bavaria)-based cement maker Märker Zement GmbH, which has a history dating back some hundred years. Märker currently operates ultramodern lime kilns at its Harburg and Herrlingen works where eco-friendly, high-efficiency processes are used to produce lime of the highest quality.

Lime production provides a basis for the manufacture of various processed products. Innovative techniques combined with a forward-looking investment policy have helped make Märker one of the leading producers of lime in southern Germany. 

Construction of the new lime kiln at Herrlingen quarry in the background. (Foto: staff of consortium)
Going underground

Experts have been predicting for years that the non-metallic minerals industry would go underground. A few pits did take this step, usually for environmental reasons, i.e. to reduce the dust and noise nuisance for the local residents. This included our client Märker Kalk GmbH, whose resources at the Herrlingen quarry in Baden-Württemberg were nearing exhaustion.

There was no prospect of obtaining yet another approval for surface quarrying close to a residential district. The logical move was to consider using underground mining methods and as a result the Mähringer Berg project was put into action.

Planning considerations

Planning considerations were based market conditions and the geology of the deposits ‘All is dark ahead of the pick’- this old mining saying had twofold significance when it came to the Märker project:

It applied firstly to the client’s general project for developing the underground workings and building a new kiln to process the high-grade white lime. This first required a lengthy planning and clarification process that included financing arrangements, technical equipment, licences and partners. All these procedures were carried out against a background of increasing demand for the end product. But now that every - thing is ready for ‘harvesting’ the market appears to be much less favourable. The global economic crisis, which has been accompanied by a fall in demand, has left its traces. Nevertheless, as soon as the markets recover this long-term investment project will be delivering the expected returns.

And secondly to the geology in the strict sense of the word. In 2001 an exploration roadway was driven and a small-scale test extraction undertaken. And the geology, it has to be said, was perfect.

However, after the contract to develop the Mähringer Berg deposits was awarded in June 2007 to the Mähringer Berg joint venture, comprising Schachtbau Nordhausen GmbH and Thyssen Schachtbau GmbH, it was found that the geological conditions encountered along the 1,350 m of drivage differed somewhat from the original predictions and findings.

Rockbolts, weldmesh panels and shotcrete had to be employed on a large scale in the long-term excavations and roadways. However it is hoped that the poor geology encountered in some of the roadway developments will not be repeated to the same extent in the excavations made to the north of the same extraction zone.

The ‘Mähringer Berg deposits’ development project

Excavation work on the conveyor road, parallel headings, crosscuts and rooms for the crusher, transformer and mine fan began on 09.09.2007. The highly karstified strata called for the highest safety standards and required a lot more support than had been planned. Roadways with profiles of 32 to 36 m² would have to serve as the main production arteries for decades to come. The crusher room, for example, was not spot-bolted but instead supported by a 30 cm-thick coating of shotcrete, two layers of weldmesh and rockbolts up to 5 m in length. After each round of shots the heading team had to reassess the condition of the strata and determine in collaboration with client the most appropriate measures to be used for support and reinforcement.

In order not to contaminate the high-quality lime shotcreting was only permitted in the cut-through road. More than 3,000 tonnes of this material were eventually used in all the infrastructure cavities.

The increased safety measures, additional length of drivages required for the parallel heading and crosscuts and the need for additional ripping at the roof and ancillary support work all combined to delay the completion of the project by nearly half a year.

The development work was completed at the end of 2008. A total of 1,350 m of roadways and some 49,000 m³ of cavities had been excavated at an average pull of 3.14 m and with an explosives consumption rate of about 1.7 kg/m³. Each complete pull took 18.5 hours to execute, including time for ancillary operations and unscheduled support and reinforcement work.

The shotfiring pattern, length of pull and choice of explosive all had to be coordinated so as to maximise the heading performance, reduce the degradation rate and keep the proportion of debris less than 20 mm in size below 35%. Of course this could not always be achieved in those karst joints that were filled with loam and silt. An upper limit had also been placed on the vibration levels due to blasting, with no firing permitted at all between ten in the evening and six in the morning.
Available resources and equipment

This outstanding performance was achieved by a mixed team representing both JV partners, whose Members were soon working as a close-knit unit. Some of the drivage work was undertaken using the multiple-entry system with a team of between 13 and 17 men. The heading crew was supported by some very effective equipment, comprising the AC 352 S twin-arm drill jumbo from the Gehren project, which was used for drilling the shotholes and rockbolting holes and installing the weldmesh screens, an ITC 312 H3 Schaeff excavator for loading and salvage work and two Terex TA 30 dumper trucks for haulage duties between the intermediate stores and the tunnel portal. As well as ventilation equipment, a compressor and a shotcrete supply bin the operation was also supported by a Komatsu WA 470 loader with a payload capacity of 4.2 m³ and a Merlo P30.13 telescoping forklift.

Conclusion

These performance levels could not have been attained without some terrific support and cooperation from the client. We would therefore like to take this opportunity to express our appreciation for this back-up and for the hospitality served up in the form of pretzels at our regular meetings. As well as providing site supervision the client was also responsible for mine planning approvals, rescue services and project planning.

The client’s satisfaction with the quality of the mining activities and support measures was borne out by the fact that the JV was awarded a follow-up contract for the complete electrification of the mine. This work essentially comprised the installation of a transformer room and the electrification of all lighting, underground fans, crusher and conveyors.

Drilling blasting holes and bolt-setting holes (Foto: staff of consortium)

ITC and dumper in action (Foto: staff of consortium)
The future

All work was successfully completed and the new mine infrastructure was handed over to the client right on time for the start-up of the new lime kiln in April 2009. Output from the surface quarry can now be scaled down – to be replaced by production from the new underground workings. At this point we would like to wish Märker Kalk GmbH every success in its new venture along with a rapid upsurge in market demand. Schachtbau Nordhausen GmbH and Thyssen Schachtbau GmbH also hope that the Gehren barytes mine will see raw-materials prices stabilising again and that the operators will have the entrepreneurial courage to continue the process that commenced with the underground development work.

This outstanding performance was achieved by a mixed team from both JV partners, whose members were soon working as a close-knit unit. (Foto: staff of consortium)

Marbled lime and what it can become to the drill steel. (Foto: staff of consortium)

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Tribological System-Adapted Wear-tests of Pseudoalloys containing Tungsten Carbide, for Application in Mining

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In mining, machines and equipment components are subject to extreme strains. Since wear and corresponding downtimes pose an enormous economical damage, it is imperative to select the material according to the incurring strain. With the conventional standardized inspections of the ASTM tribological systems existing in reality cannot or can only be replicated incompletely. Therefore a test bench was set up, which corresponds to tribological systems existent in mining machines, crushers, solid matter pumps and processing plants, so that material can be qualified with regard to their resistance to a combined percussive and abrasive strain. The object of the presented tests are various types of tungsten carbide pseudo alloys.

Introduction

Wear testing with standardized test procedures, mostly according to ASTM norms, are assigned to the category 6 “Model test with simple test bodies”. The test setup is deliberately kept simple and therefore, despite the multitude of standardized tests, it is not always possible to apply the results, since these tests cannot map the tribological systems that exist in reality.

Validity of wear tests increases with approximation to reality, ending with the category “Field test”. Apart from the enormous time expenditure and costs, the problem of material selection arises, particularly in construction of new plants.

A cost-effective alternative is the tribological system-compatible wear test that is offered at the ISAF. In this test the material testing, particularly for problems regarding wear, is done by deviating from standards. A specific analysis of the tribological system provides all parameters. Apart from the involved friction pairing, the intermediate media, ambient media, temperature, type and amount of strain are the determining parameters for a wear in form of surface changes and loss of material. Pic 2

<table>
<thead>
<tr>
<th>Category</th>
<th>Type of test</th>
<th>System structure</th>
<th>Trend of the transferability or measuring possibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Fieldtest</td>
<td>complete machine/comple plant</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>Test bench with entire machine or plant</td>
<td>complete machine/comple plant</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>Bench test with aggregate or assembly</td>
<td>complete aggregate/comple assembly</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>Test with uncharged component or reduced aggregate</td>
<td>extracted components/reduced aggregate</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>Strain-like test with reference blocks</td>
<td>Parts with comparable demand</td>
<td></td>
</tr>
<tr>
<td>VI</td>
<td>Model test with samples</td>
<td>single samples</td>
<td></td>
</tr>
</tbody>
</table>

Pic 1: Categories of the wear test [1]
Examples in the literature show the importance of accurate knowledge on the tribological system. In the area of abrasion wear, the upper shelf-lower shelf characteristics of material is known. Already small increases in the hardness of the abrasive material can massively increase loss of material, Picture 3. The change in the wear mechanism, in relation to the strain angle $\alpha$ in erosive wear shows that small changes already have big effects on wear behaviour of material, Picture 3. Different materials show their maximum in various strain angles. While highly hard materials undergo a massive material loss in wear by impingement (90° impact angle), softer material like Polyurethan (PUR) often show a minimum. The reason is the change in the damage mechanism, since in wear by impingement, ductile materials elastically absorb the impact energy, so that an elastic blow to the individual grains occurs. Highly hard material that is less ductile has a different reaction, so that the kinetic energy of the abrasive goods is converted in the material and thus leads to breaking out of material from the surface. In small strain angles a grove forming strain is predominant. Due to the almost parallel direction of movement of the abrasive good to the material surface, the application of energy is significantly lower. While in this case highly hard materials offer a good wear resistance, ductile materials can hardly resist this cutting strike.

These two cases from the literature already show the importance of a wear test that is compatible to tribological systems, with regard to optimized endurance of machines and plants.

The wear-testing of materials in combined strains, like for example in hammer mills and rock crushers, proves particularly difficult. For these tests the Institute of Welding and Machining of the Clausthal University of Technology uses special setups, Picture 4.

The combined strain from abrasion and hitting component leads to a changed wear pattern, Picture 5. The demolition of the hard phase portions can clearly be seen. With sole abrasion a washing out of the softer matrix material can be seen.
Pic. 3:
upper shelf-lower shelf characteristics of material in abrasive wear (left). Changes in the wear mechanism in erosive wear (right) [1]

Pic. 4:
Schematic setup of the test bench for combined hitting/jabbing and abrasive strains at the ISAF, TU Clausthal
Experimental Study

In highly abrasive wear strains metal-matrix-composites (MMC) have proven of value, because of their characteristics. They combine advantages of a tough matrix, based on nickel, cobalt or iron, together with hard material that protects against wear like carbide, boride and nitride. As a proactive-oriented method the samples were produced with plasma transferred arc welding (PTA), since this method can cost-effectively achieve layer depths of 2 to 3 mm in one layer. Another advantage of the PTA method is a highly controllable energy input, which helps achieving very low degrees of mixing of a few percent.

Various tungsten carbides were used for the tests, in combination with a commercially available NiBSi-alloy as matrix material. Broken mono crystalline tungsten carbide, broken Fused Tungsten Carbide (FTC) und spheric Fused Tungsten Carbide (SFTC), Tab 1. Beside the type of the influence of the carbon concentration and the grain size of the carbide on the wear opposition was also analysed. The mixing ratio of hard material to matrix powder of 60 to 40 mass percent was held constant for all tests like the welding parameters, tab. 2.

In addition to the percussion wheel, three more test benches were used, out of which two were standardized according to ASTM. The Miller test, specified according to ASTM G75-07, originates from the petroleum industry, Picture 6.

The sample is directed with a velocity of 20 m/min, oscillating in a defined suspension of water and aluminum oxide. The down force is 22,24 N, at a test time of six hours, which is passed in three intervals [2].

<table>
<thead>
<tr>
<th>Type</th>
<th>C-concentration</th>
<th>Size in µm</th>
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<tbody>
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<th>Plasma voltage in V</th>
<th>Welding speed in mm/min</th>
<th>Oscillation width in mm</th>
<th>Powder feeding in g/min</th>
<th>Mixing ratio NiBSi/W(S)C</th>
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<td>102</td>
<td>40</td>
<td>120 +/- 4</td>
<td>40/60</td>
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</table>
The test according to ASTM G65-04, Picture 7, is conducted with rounded quartz sand as abrasive good. The sand is inserted into the gap between the gummed steel wheel and the material sample, with a mass stream of 300 – 400 g/min. The sample is pressed on with a force of 130 N. The method A of the standard requires a wear path of 4309 m\(^2\).

The ISAF offers this test in a modified version that includes a steel wheel without a rubber layer. This results in a harder wear strike, since in this test no abrasive good can be pressed into the rubber layer. All other parameters remain the same.

The fourth test bench is the percussion wheel test, which is shown in picture 4. This test bench which is not standardized, also uses rounded quartz sand as abrasive, which is being led into contact with the rotating striking element. The power of impact is also captured on-line.
Results

The results of the test according to ASTM G 75-07 show major advantages with spherical carbides, picture 8. A significant difference between the broken FTC and TC cannot be determined.

One reason for the good results with spherical carbides lies in the relatively low load, which leads to the fact that the softer matrix between the carbides is mostly washed out, while the carbides themselves are struck relatively lightly, Picture 9. The spherical carbides stay longer in the matrix form-closed, since they can only fall out, in case the matrix is worn out deeper than the sphere radius. Due to the irregular form and distribution of the broken FTC and TC, these can fall out more quickly, since in this case the supporting effect of the matrix is not given.

The tests on the material according to ASTM G65-04 very clearly show the different influences, such as grain size, line pitch and type of carbides, picture 10. It becomes clear that, contrary to the Miller test, the higher contact pressure of 130 N not only causes the abrasion of the matrix, but also the demolition of the carbides. In contrast to the monocrystalline TC, the FTC is lightly dissolved at the border areas during build-up welding, which enables a better connection to the matrix material. In addition the TC is considerably more brittle and therefore breaks more quickly. Due to the chosen mass ratio during mixing of the powder, the coating layer contains less carbides in terms of numbers with increasing carbide sizes. The influence of the line pitch is illustrated in material 5, Picture 11. According to the standard the quartz sand used in the test setup has a grain size of 200 to 425 µm. Since with Material 5 the line pitch partly exceeds 200 µm, here the abrasive good can fully damage the matrix, which leads to an increased drop out of the FTC spheres.

Pic. 8:
Results of the ASTM G75-07 Millertest

Pic. 9:
Wear pattern ASTM G75-07 (left: material 3, right: material 6)
The highest material removal is achieved in the modified version of the friction wheel test with a steel wheel, picture 12. Due to the fact that the abrasive goods cannot be pressed into the surface, which happens in case of the gummed wheel, higher forces occur in the contact gap between sample and the steel wheel. This causes on one hand a higher application of energy into the coating layer, along with a higher damage potential, on the other hand it leads to a grinding of the abrasive good. The consequence is those considerably smaller particles contribute to the damage, and can overcome the protection of the smaller line pitch in the friction gear test with rubber wheel. In this strain, carbide sizes of material 5 are of advantage. Occasionally these stick out highly, so that the steel wheel runs on a carbide layer and the fine abrasive particles bypass the FTC through the gap between wheel and matrix, picture 13.

The percussion wheel test, which was adapted to the tribological system of hammer mills, shows clear advantages with the spherical FTC, picture 14. The high brittleness of the monocrystalline TC of the material 6 leads to a high fragmentation of carbides due to the hammering strain, picture 15. Despite the demolition of hard phases, the spherical FTC offers a higher wear protection than the broken ones. The reason is partly the higher ductility of the...
**Pic. 12:**
Results of steel wheel test

**Pic. 13:**
Cross-section polish after steel wheel test (left: material 5, right: material 4)

**Pic. 14:**
Results hammer wheel test
spherical FTC which leads to a chipping off of only small portions, as well as the form of the carbides. Since here the abrasive component has a smaller influence than in the previous tests, the matrix is less worn out, so that the spherical carbides stay long in the wear protection layer.

**Summary**

The examinations show that in a highly limited material selection already big differences in wear behaviour can occur. Based on the test method, various reactions of tungsten carbides to the strains were achieved. Mining in particular demands a great deal of wear protection material, which is usually selected based on standardized test methods. However it becomes evident that this can lead to a wrong decision, since the strains during operation are not displayed in the model experiment according to ASTM, and as such the wear behaviour of the material is not tested under operation conditions. Since during the Miller test according to ASTM G75-07 the materials 3 and 4 offer a higher wear protection, the material abrasion of the materials 1 and 2 in the friction wheel after ASTM G65-04 is significantly lower. In the steel friction wheel modification the material 5 clearly lies below the other material, picture 16.
Bibliography


Univ.-Prof. Dr.-Ing. Volker Wesling

Univ.-Prof. Dr.-Eng. Volker Wesling studied at and received a doctorate from the Clausthal University of Technology. After his graduation in 1993 and several years of working in the mechanical engineering industry he responded to the call of the TU Clausthal, where he took the responsibility of the Institute of Welding and Machining. From 2005 to 2008 he was Dean of the course mechanical engineering/process engineering of the faculty of mathematics/informatics and mechanical engineering. In 2007 he was appointed honorary professor of the KTSU Bishkek (Kyrgyzstan). Since 2009 he is vice president for research and transfer of technology of the TU Clausthal. In addition to wear protection and the classic production and joining technologies the main focus of his teaching and researches are, among others, in the area of special methods like high frequency welding or laser-hand welding.

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Introduction

The advantages of screw conveyors, like the simple and robust design, the low costs for setup and maintenance, the low susceptibility to interference and particularly the dustproof design, all these often lead to application of screw conveyors for continuous transport of bulk materials. Conventional screw conveyors are suitable for transport of dusty, granular and slightly moist bulk materials. The application of screw conveyors in bulk materials handling is shown in picture 1. The demands on screw conveyors with regard to reliability, performance and economy, as well as energy efficiency and conservation of environment have considerably risen in the past years.

Like all other continuous conveyors for bulk materials, screw conveyors need to be reliably designed, to avoid down times or over-dimensioning. Following the researches done in the past years by the Institute for Materials Handling Material Flow Logistics on methods of dimensioning and sizing for horizontal to slightly inclined and vertical screw conveyors, respectively, with this project the Institut is aiming at closing the gap for highly inclined screw conveyors.

Screw conveyors mainly consist of a conveyor trough or tube and the screw, consisting of a screw shaft and spiral. Under certain conditions during horizontal and slightly inclined conveyance, the movement of the bulk material can be seen as purely translational. In higher inclined ranges, this translational movement is superposed by a rotational portion, up to the extreme case of vertical conveyance, in
which only the rotational movement of the bulk material dominates. According to Vollmann [1], the inclination $\beta$ and the rotation speed $n$ of the screw conveyor have significant influence on the type of conveyance. As shown in picture 2, the purely translational conveyance (Range I) takes place up to a certain critical angle, which is dependant on the rotation speed. Range II lies in higher angles of inclination and rotation speeds, but below a certain limiting rotational speed, in which the translational and rotational conveyance overlap. In case the rotation speed is increased, the bulk material is entirely moved rotationally (Range III). Due to gravity forces, from a second limiting inclination angle a translational portion is not possible any more. In range III and partly in range II a conveyance is only possible, if the screw has a certain minimum rotation speed. This minimum rotation speed is necessary to keep the bulk materials at the conveying tube through centripetal force and prevent it from sliding down.

**State of the Art**

As mentioned above, during the last years, the Institute for Materials Handling Material Flow Logistics has embarked on many activities regarding description of screw conveyors and the development of guidelines for sizing and dimensioning. Particularly the last tasks ([2], [3]) were implemented with the goal of creating practicable methods that are easy to handle for the operator and were verified by Blomeyer [4]. This resulted in development of a method for horizontal to slightly inclined screw conveyors, which is strongly based on DIN 15262 [5]. As such, both methods calculate the conveyed volume flow, according to the approach known from the continuum mechanics, which is that the flow rate equals the product from the flown through area and the velocity component in the direction of the flow, as follows:

$$I_v = A \cdot v_a = \Phi \cdot \frac{1}{4} \cdot D^2 \cdot \pi \cdot S \cdot n$$  \hspace{1cm} (1)

From the filling level $\Phi$, the screw diameter $D$, the screw pitch $S$ and the rotation speed $n$. The approach is based on the fact, that due to the limiting area of validity, there is a purely translational movement of the bulk material. The same approach is followed in both methods for calculation of the required input power $P$. Apart from the lifting power which can easily be determined, all friction portions are combined and calculated similar to the Coloumb friction in
the classical mechanics through a fictitious total friction coefficient, the progress resistance coefficient \( \lambda_{V'} \), from a known reference value, in our case the volume flow \( I_{V'} \).

Thus the input power is calculated from

\[
P = \rho \cdot I_{V'} \cdot g \cdot (\lambda_{V'} \cdot L + H)
\] (2)

The bulk density \( \rho \), the volume \( I_{V'} \), the progress resistance coefficient \( \lambda_{V'} \), as well as the geometry parameters conveying length \( L \) and conveying height \( H \).

Entscheidender The decisive difference in the new method is the definition of the progress resistance coefficient \( \lambda_{V'} \) as a multidimensional parameter. While the DIN 15262 defines the progress resistance value as a constant value that is specific to bulk materials, the new method takes stock of the knowledge gained through experiments, so that the progress resistance coefficient depends on geometry-, operational and bulk material parameters. The calculation can be obtained from the papers of Blomeyer [4].

Methods of dimensioning and sizing for vertically operated screw conveyors are also mentioned in the above-mentioned tasks. These methods were realized as partly graphic methods. Since, as mentioned above, purely rotational conveying characteristics are present in a vertical conveyor, the bulk material in the conveyor is conveyed upwards in a helix. Thus the velocity of the goods is reduced by a rotational portion, the angular speed of material \( \omega_G \). Therefore the achievable volume flow \( I_{V'} \) is calculated as.

\[
I_{V'} = A \cdot v_a = \phi \cdot \frac{1}{4} \cdot D^2 \cdot \pi \cdot S \left( n - \frac{\omega_G}{2\pi} \right)
\] (3)

The angular speed of material \( \omega_G \) can be calculated through an equation of motion. However, since this should be done separately for each individual case, determination of the volume flow is offered as a graphic method. A respective diagram for filling levels of \( \phi = 0.4 \) is shown in picture 3.

The calculation of the required driving power is done similar to the procedure in range I. Again a total friction power is calculated, which is a product of a conveying factor and the analytical determined power based on the friction against the tube and the screw. The power loss through lifting of the bulk material is again added. Analog to the progress resistance coefficient, the conveying factor is a parameter that is dependant on geometry-, operational and bulk materials parameters. Accurate calculation formulas, as well as further diagrams for determination of volume flow can be obtained from the paper of Rong [6].

In previous years the Institute for Materials Handling Material Flow Logistics (fml) has also done examinations on highly inclined screw conveyors. Building on the task of Gabler [7], Vollmann [1] developed even more detailed calculation algorithms and programmes, which allow for calculation of volume flow and driving power of highly inclined screw conveyors. These are based on

![Diagram to determine the volume flow in vertical screw conveyors](image-url)
the analytical observation of the stress ratio inside the bulk material and at the points of contact with the screw conveyor. In order to do this, the bulk material in the screw conveyor is divided into segments, for which equations of motion are solved. With this method the bulk material, with its internal sliding occurrences, as well as the influences through the friction at the tube, can be pictured accurately. The volume flow can be calculated by adding the individual velocities and friction forces. An approximate solution can be determined for the driving power.

Although these observations describe the conveyance in inclined screw conveyors in a good way, they are not sufficient for an approach to a simple and practical calculation method. The reason is the required complexity of the analytical model, which cannot be described by a self-contained solvable set of equations. The solution of any specific problem therefore needs numerical methods, which can only be tackled with computer assistance. Another disadvantage is that only the conveyance range III can be described analytically, therefore the method is only valid for this area. Nevertheless the method delivers valuable conclusions of the conveyance behaviour and the influence of the various parameters, and is therefore an important basis for the current research.

Procedure and Goal

The following steps were followed to achieve the goals of the project, which are the development of a simple and safe method for dimensioning and sizing for highly inclined screw conveyors for bulk materials, taking into consideration construction –, operational-, and bulk material parameters:

• Data for highly inclined screw conveyors are obtained through tests, simulations and assessment of analytical calculation methods of previous works. Hereby the main focus is on conveyors that are operated with high rotation speeds and high filling levels. The influencing parameters to be examined are rotation speed, inclination, filling level, geometry of conveyor as well as the conveyed bulk material. Velocity and power parameters are determined as command variables. In their nature these parameters correspond to the progress resistance coefficient or the conveyance factor in horizontal to slightly inclined or vertical screw conveyors, and they capture the influence of the examined parameter.

• In the second step the influence of the varied geometry –, operational- and bulk materials parameters is analyzed. The relationships that are found here are the basis for the development of dimensioning and layout methods in the following step.

• In the last step, formulas are developed from the obtained data of parameters and the derived dependence through statistical regression analysis. These formulas allow for easy and safe calculation of the coefficient of velocity and the coefficient of performance. The obtained formulas are then assessed with regard to their quality.

Models for calculation of volume flow and performance

The dimensioning and sizing methods to be developed should orient themselves at the calculation guidelines that are known from DIN 15262. Therefore the following section presents the order of the formulas and the way the above-mentioned parameters are integrated.

Calculation of obtainable Volume Flow

The calculation of the volume flow is again done as a product of the axial velocity $v_{ax}$ and the flown through cross-sectional area $A$. This area is described as a circular ring through the screw diameter $D$ und the shaft diameter $d$. Since the screw conveyor is not completely filled, the area is reduced by the filling level $\phi$ and calculated according to:

$$ A = \phi \cdot \frac{1}{4} \left( D^2 - d^2 \right) \pi $$ (4)

In highly inclined conveyance, the translational and rotational movements of the goods overlap and an analytical description is no more possible. However, due to the occurrence of a rotational component, all parameters being the same, the axial velocity is in any case lower than the feed in a horizontal conveyance. This has been proven by Vollmann [1]. The axial velocity of the bulk material $v_{ax}$ in an inclined screw conveyor can be seen as a portion of the axial velocity of a horizontal conveyor:

$$ v_{ax} = S \cdot n \cdot \zeta $$ (5)
Hereby $\zeta$ is the coefficient of velocity, as mentioned above, that lies in the interval of $0 \leq \zeta \leq 1$. The set limits of the parameter can vividly be described: On one hand there is no conveyance for $\zeta = 0$. As demonstrated in picture 2, this case can also occur in screw driving speeds higher than $n = 0 \text{ 1/s}$, if it falls below the minimum driving speed needed for conveyance. On the other hand the maximum axial velocity of material of the horizontal conveyance is achieved for $\zeta = 1$. With the last two equations the achievable volume flow in inclined screw conveyors can be summarized as

$$I_v = A \cdot v_a = \varphi \cdot \frac{1}{4} \left( D^2 - d^2 \right) \pi \cdot S \cdot n \cdot \zeta$$ (6)

Hereby the coefficient of velocity $\zeta$ is the last unknown value and is determined as the result of empirical tests, depending on the described influencing factors.

**Calculation of Driving Power**

In an inclined screw conveyor the required driving power also results from a range of different loss portions. Apart from the lifting power to overcome the difference in height, there are mainly friction powers between the bulk material and the geometry, as well as power losses inside the bulk material. From these only the lifting power $P_{hub}$ can easily be determined analytically. This is calculated from the volume flow to be conveyed $I_v$, the bulk density $\rho$ and the conveying height $H$ according to formula:

$$P_{hub} = I_v \cdot \rho \cdot g \cdot H$$ (7)

For further power losses through friction, among others, the following are to be mentioned [1]:

- Friction power between good and inner wall of the tube
- Friction power between good and screw spiral
- Friction power between good and screw shaft
- Power loss in the intermediate bearings
- Gap losses
- Dissipated power in shear planes
- Power losses from acceleration of goods

These loss portions cannot be calculated easily, although some analytical approaches exist to describe them [1], [6], [7], [8]. These approaches apply a fictitious total friction power – based on the semi-empirical approach of Fottner [9] – which describes all friction parts with the help of empirically determined parameters. Also in the approach for the friction power the principal approach of DIN 15262 [5], which was also applied by Gabler [7] and Vollmann [1] is used. Here the friction power is calculated similar to the principle of the Coloumb friction, as the product of a fictitious conveying factor with the normal force $F_n$ on the conveying tube and the absolute velocity of material $v_G$.

According to Rong [6] the normal force on the conveying tube is proportional to the conveyed volume flow $I_v$. The acceleration $a$ of the mass is dependant on the type of conveyance - translational and rotational portions - and is initially disregarded. With the bulk density $\rho$, the conveying length $L$ and the axial velocity of the good $v_{ax}$ the normal force $F_N$ results as:

$$F_N = \frac{I_v \cdot \rho}{v_a} \cdot L \cdot a$$ (8)

According to Vollmann [1], the absolute velocity of goods can be presented with inclusion of the velocity parameter $\zeta$ with the screw diameter $D$, the rotation speed $n$ and the screw pitch $S$:

$$v_G = D \cdot \pi \cdot n \cdot \left( 1 - \zeta \right) \cos^{-1} \left[ \arctan \left( \frac{\zeta}{1 - \zeta} \cdot \frac{S}{D \cdot \pi} \right) \right]$$ (9)

In order to have a simple and practical dimensioning method for the determination of the power losses through friction, the portions depending on the coefficient of velocity $\zeta$ as well as the unknown fictitious conveyance factor are combined to the coefficient of power $\lambda$. The acceleration $a$ of the mass in the screw conveyor is also included as portion of the gravitational acceleration $g$. This is required, as the type of conveyance is not known. However this is of decisive importance for the type of acceleration that influences the bulk material. In case of a purely translational conveyance, the bulk material is only subjected to gravitational acceleration. In case a rotational portion is included, the bulk material is also influenced by centripetal acceleration, and in case of a vertical screw conveyor, this type of acceleration is exclusively present. Therefore the following correlation results for the fictitious total friction power:

$$P_{Reib} = \lambda \cdot \frac{D}{S} \cdot I_v \cdot \rho \cdot g \cdot L$$ (10)

As such the components of the required power for conveyance in an inclined screw conveyor are known and can be summarized as follows:

$$P = P_{Reib} + P_{hub} = I_v \cdot \rho \cdot g \left( \frac{\lambda \cdot D}{S} \cdot L + H \right)$$ (11)
Thus, also in equation (11) the only unknown factor is the coefficient of power $\lambda$. After its determination, the conveyance power of an inclined screw conveyor can easily and practically be calculated. The determination of the coefficient of power $\lambda$, as well as the coefficient of velocity $\zeta$ is described in the following.

**Data Collection**

Various methods are used for collection of needed data to determine the empirical coefficients: Interpretation of the above-mentioned analytical calculation methods, experimental tests in a large-scale test plant for screw conveyors, as well as simulations according to the Discrete Elements Method. The application of different methods of data collection allows for collection of data for all (border) areas of the application area.

**Experimental Tests**

Experimental tests are conducted in the large-scale test plant at the Institute for Materials Handling Material Flow Logistics (fml). In terms of its geometric measurements, as well as its technical data, this plant more resembles an industrial conveying plant than a model test plant. The plant was sized for a nominal volume flow of $I_V = 0.0275 \text{ m}^3/\text{s}$; the constructive design of the conveyor units allows for the application and analysis of fine-grained, coarse-grained to lumpy bulk materials like e.g. grains, coal and sulfur.

In order to achieve the goal of the current work, it was necessary to expand the operational area to highly inclined conveyance (up to $\beta = 60^\circ$). In order to do so, the existing large-scale test plant was rebuilt. The test plant was complemented with conveyance and measuring facilities and substantively expanded with regard to its functionality. Currently the test plant consists of the three conveying units, feeding device, vertical screw conveyor and inclined screw conveyor. The technical data of the screw conveyors are summarized in table 1.

During the test, the bulk material is deposited in a 6 m x 3 m x 1.5 m bunker. From there it is milled in tracks and layers with the help of the feeding device and conveyed into a second bunker through the vertical and inclined screw conveyor. The supplied volume flow can be preset with the setting of the milling depth and the feeding velocity, together with the width of the feeding device. The rotation speeds of the conveyors can individually and continuously be adjusted through frequency converters. The interpretation of the tests is also done through the frequency converters.
Characteristic data like active current intake and rotation speeds of the individual screw conveyors are continuously recorded during the test in the frequency converter. In addition the measurement technique installed at the test site allows for recording of other important measurement data. Apart from the inclination of the screw conveyor and its filling level, the conveyed mass flow is recorded through balance weighing of the entire content of the bunker. These values are also recorded as analog signals in the frequency converter. The data saved in the frequency converters are sorted with an analysis software and combined in a result file for further processing. Thus the mentioned influencing factors, rotation speed, filling level and inclination can directly be set or at least be continuously monitored. In addition to these parameters the characteristics of the bulk materials also have an influence on the conveying process and the power requirement. Therefore the tests were repeated for various bulk materials. The parameters to be examined and the respective parameter levels are summarized in table 2.

Finally, the command variables to generate the dimensioning and layout guidelines can be calculated from the recorded data. The empirical coefficient of velocity \( \zeta^* \) can be calculated from the measured mass flow \( I_m \) according to

\[
\zeta^* = \frac{4 \cdot I_m}{\rho \cdot \phi \cdot (D^2 - d^2) \pi \cdot S \cdot n}
\]  

(12)

With the bulk density \( \rho \), the filling level \( \phi \), the screw diameter \( D \), the shaft diameter \( d \), the screw pitch \( S \), as well as the rotation speed \( n \). At the same time the empirically determined coefficient of power \( \lambda^* \) can be calculated from the recorded active current \( I_{\text{Work}} \)

\[
\lambda^* = \frac{\sqrt{3} \cdot U_{\text{eff}} \cdot I_{\text{Work}} \cdot \eta - P_{\text{Leer}}}{I_m \cdot g \cdot \frac{D \cdot S}{S} \cdot L} - \frac{S \cdot H}{D \cdot L}
\]  

(13)

Table 2:
Examined parameter levels in the tests

<table>
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<th>Parameter</th>
<th>Unit</th>
<th>Parameter levels</th>
</tr>
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<tbody>
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<td>Rotation speed ( n )</td>
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</tr>
<tr>
<td>Inclination angle ( \beta )</td>
<td>[°]</td>
<td>20, 30, 40, 50, 60</td>
</tr>
<tr>
<td>Filling level ( \phi )</td>
<td>[-]</td>
<td>0.2, 0.3, 0.4, 0.5, 0.6</td>
</tr>
</tbody>
</table>

Taking into consideration the effective voltage \( U_{\text{eff}} \), the motor- and gear-efficiency \( \eta \), the idling drive power \( P_{\text{Leer}} \), the achieved mass flow \( I_m \), the conveying length \( L \), the screw pitch \( S \), the screw diameter \( D \) and the conveyance height \( H \).

Simulations according to the Discrete Element Method

Furthermore, data are obtained through simulations according to the Discreet Elements Method (DEM). In principle such simulations are numerical experiments, in which apart from the geometry of the conveyor, the individual bulk particles are pictured as discrete elements. In each calculation step Newtonian equations of motion are solved and allow for calculation and simulation of discrete, continuous procedures. In principle this simulation method is very simple, however previously it was limited by the very high number of particles to be considered. It was only by the application of modern computers with multi-core technology and high calculation speed that it became possible to also accurately calculate complex simulations with several tens of thousands particles and high resolution in acceptable timeframes. The simulation program EDEM of the DEM Solutions LTD company is applied in this test.
The simulations are done with a PET granulate as bulk material. This granulate is also used in the real test stand of the Institute and as such its characteristics and behaviour is known. Since the simulations can only be done with enlarged particles, due to the expected calculation time, the simulated bulk material has to be calibrated. In order to do so the tests to determine bulk material characteristics are done in real terms and are replicated in the simulation. Tests are selected for determination of the bulk density, the angle of repose and the wall friction. The test design, as well as the simulation models for calibrating are oriented at FEM 2481 [11]. For calibration purposes, the simulation parameters are changed iteratively to the extent that the behaviour of the particles in the simulation model corresponds to the real bulk material behaviour with acceptable accuracy.

In addition to the simulated bulk material, the conveyor itself is obviously of fundamental importance. The measures of the conveyor are initially chosen in analogy to the existing test stand. Thus the simulation model can be verified with data from the test plant. All geometry models can directly be loaded into the simulation model through the CAD-data-interface. The simulated model is presented in picture 5.

Finally the simulated operation parameters of the screw conveyor has to be determined. The rotation speed \( n \), the inclination \( \beta \), the filling level \( \phi \) as well as the screw diameter \( D \) are diversified. The parameter levels to be simulated are listed in table 3. The simulation planning is fractional.

The mean axial velocity of material \( v_{ax} \) and the torque measured at the screw shaft \( M \) are analyzed as command variables. The simulated coefficient of velocity \( \zeta^* \) calculated from the readout command variables the interrelation

\[
\zeta^* = \frac{v_{ax}}{S \cdot n} \tag{14}
\]

From the axial velocity of material \( v_{ax} \) and the pitch \( S \) and the rotation speed \( n \). The simulated coefficient of power \( \lambda^* \) is calculated according to

\[
\lambda^* = \frac{2 \pi \cdot n \cdot M \cdot S}{I_v \cdot \rho \cdot g \cdot L} - \frac{S \cdot H}{D \cdot L} \tag{15}
\]

From the rotation speed \( n \), the torque \( M \), the screw pitch \( S \), the achieved volume flow \( I_v \), the bulk density \( \rho \), the conveying length \( L \), the conveying height \( H \) and the screw diameter \( D \).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Parameter levels</th>
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<tbody>
<tr>
<td>Rotation speed ( n )</td>
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<td>Inclination angle ( \beta )</td>
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<td>30, 45, 60</td>
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<tr>
<td>Filling level ( \phi )</td>
<td>[-]</td>
<td>0.2, 0.4, 0.6</td>
</tr>
<tr>
<td>Screw diameter ( D )</td>
<td>[m]</td>
<td>0.2, 0.26, 0.4</td>
</tr>
</tbody>
</table>

Table 3: Simulated parameter levels of the DEM-Simulations

Interpretation of Analytical Calculation Methods

As described above, the calculation methods of Vollmann [1] offer good results for determination of volume flow, although the calculation is very complicated and only possible numerically.

Nevertheless it seems sensible to use these calculation algorithms for parameter levels for which tests are not possible or simulations are too time consuming. In addition parameter combinations, which are also used in simulations and tests, are also calculated, in order to validate the method. The parameter levels presented in table 4 are calculated, whereby no full fractional parameter variations are conducted.
The calculation method delivers the good angular velocity of material $\omega_G$ of the bulk material in the screw conveyor. From this the determined coefficient of velocity $\zeta^*$ can be calculated through:

$$\zeta^* = 1 - \frac{\omega_G}{2\pi \cdot n} \quad (16)$$

With the rotation speed $n$.

**Creation of a Dimensioning and Sizing Method**

In the following, the data of the coefficients of velocity and power gathered up to now are analyzed with regard to the influence of the examined parameters, and they are processed for the generation of dimensioning and sizing methods. As the presentation of the individual measurements is often not sufficient to draw usable conclusions on the influence of a parameter, a locally weighted regression is used for descriptive assessment of influences. Here the correlations between parameters and command variables are estimated flexibly and free from restrictions. Therefore it offers very accurate results, which however have to be bought with a high complexity of the model: Due to the completely free configuration of the correlations it is often not possible any more to present the connections found in compact formulas, which is desired in the framework of this project. Nevertheless the graphic presentation of the modeled correlation allows a glimpse on the possible underlying effect.

Consecutively these effects create the basis for the modeling of the regression analysis. This allows for a presentation of the command variables coefficient of velocity $\zeta$ and coefficient of power $\lambda$ in a correlation formula, in accordance to the examined influence parameter. Apart from an adequate adjustment of the model to the existing data sets, the simplicity of the model is in the foreground, i.e. the calculated model should be presentable in a simple and complete form.

In conclusion the quality of the found formulas is assessed. In order to do so, the values of the parameters determined by the new formulas are faced with the determined values and the standard error is calculated. Through this the accuracy of the found formulas with regard to the actual behaviour can be assessed.

**Coefficient of velocity**

For the coefficient of velocity $\zeta^*$ a regression model should be found, subject to the parameter rotation speed $n$, screw diameter $D$, filling level $\phi$ and inclination $\beta$. As described above, in order to do so, a locally weighted regression is calculated for the determined coefficients of velocity. These are presented in picture 6, depending on the individual influencing factors. The various influences on the coefficient of velocity can be seen in the individual diagrams.

In the diagram above left the coefficient of velocity $\zeta$ is plotted on the rotation speed $n$. An initially strong positive linkage can be seen, which clearly lessens from a rotation speed of approx $n = 6 \, 1/\text{s}$. The course of the curve corresponds to a logarithm- or power function. The influence of the screw inclination $\beta$ has been presented above right. Here a reciprocal proportionality can be identified. Alternatively the curve can also be interpreted as a combination of two linear correlations with a cusp between $\beta = 40^\circ$ and $50^\circ$ inclination of the screw. The influences of filling level $\phi$ and screw diameter $D$, pictured below left and right, are evidently lowest. A slight linear influence can be seen for the filling level, a slight non-linear influence for the screw diameter.

To begin with, this sufficiently identifies the types of influence of the individual parameters on the determined

### Table 4:

Calculated parameter level according to the Vollmann [1] method

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Parameter levels</th>
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</thead>
<tbody>
<tr>
<td>Rotation speed $n$</td>
<td>[1/s]</td>
<td>2 4 5 6 8 10 13</td>
</tr>
<tr>
<td>Inclination angle $\beta$</td>
<td>[°]</td>
<td>30 40 50 60 70 80 90</td>
</tr>
<tr>
<td>Filling level $\phi$</td>
<td>[-]</td>
<td>0,2 0,3 0,4 0,5 0,6 0,7</td>
</tr>
<tr>
<td>Screw diameter $D$</td>
<td>[m]</td>
<td>0,200 0,250 0,315 0,400 0,500 0,630 0,800</td>
</tr>
</tbody>
</table>
coefficient of velocity $\zeta^*$. These correlations form the basis of the regression model for the coefficient of velocity. Initial regression calculations reveal that the influence of the rotation speed $n$ can be well approximated with a power function. The best alternative for the influence of the inclination $\beta$ as proven to be a model from two linear influences with a cusp at $\beta = 40^\circ$.

In order to simplify the model, it is sufficiently accurate to assume a linear correlation for the influence of the screw diameter. The regression model has the following form:

$$\zeta = a \cdot n^b + c \cdot D + d \cdot \varphi + e \cdot \beta + f \quad (17)$$

Pic. 6: Influence on the coefficient of velocity
The values listed in table 5 are values for the regression coefficient, depending on the screw inclination. The respective calculated standard deviation of the coefficient is indicated.

A standard deviation that is small in relation to the coefficient is a sign for a significant influence of the variable of the coefficient. It can be seen that the standard deviation for all coefficients lies at a maximum of 3% of the coefficient value, thus in all reviewed variables one can assume a significant influence.

To finally assess the quality of the regression model, the values calculated through the regression model for the coefficient of velocity $\zeta$ is compared to the determined values $\zeta^*$ and graphically presented. Picture 7 shows the corresponding estimated values $\zeta$ over the determined values $\zeta^*$. The model is the better, the closer the points are to the bisecting line.

It can be seen that there are no major outliers and the data points of the estimated values of the coefficient of velocity $\zeta$ it the bisecting line. In terms of numbers the quality of the model can also be assessed with the help of the radical of the mean square error.

$$\sqrt{MQF} = \sqrt{\frac{1}{n} \sum_{i=1}^{n} (\zeta_i - \zeta^*_i)^2} \quad (18)$$

The radical of mean square error in the current model is $\sqrt{MQF} = 0.0111$. Even in the smallest determined coefficients of velocity $\zeta^*$ this corresponds to an average deviation of smaller than 3% and proves sufficient accuracy of the calculated regression model. In order to assess, where deviations of the model lie, picture 8 shows the determined and estimated values of the coefficient of velocity in the various categories. For the sake of limiting complexity, the screw diameter parameter is not itemized, since it has the least influence and the diagrams offer very similar results. It can be seen that in almost all fields there is a good concurrence between the determined data points and the calculated model (curve). It is only in border areas that there are minor deviations.

Thus the obtained regression model is suitable for calculation of the coefficient of velocity. The achievable volume flow $I_v$ of an inclined screw conveyor can therefore simply and reliably be calculated through the equations (6) and (17).
Coefficient of power

Following the coefficient of velocity $\zeta$, the following describes the development of the coefficient of power $\lambda$. In analogy to the above method, here also a regression model, depending on the influencing factors, is developed. Apart from the parameters used for the coefficient of velocity, as the rotation speed $n$, filling level $\phi$ and inclination $\beta$, the determination of the coefficient of power needs the additional consideration of characteristics of the bulk material, as it has significant influence on the friction behaviour. In order to do so, initially the bulk density $\rho$, as well as the friction values against screw pitch and tube $\mu_s$ and the inner friction $\mu_i$, as influencing variables of the bulk material, have to be reviewed. Here it is assumed that the friction coefficient against screw pitch and tube is identical. The material used in screw pitch and tube is steel. The parameter screw diameter $D$ is not taken into consideration, since according to the results up to now, it has no significant influence on the coefficient of power $\lambda$. However it should be noted that, according to the linkages stated in section 4.2, the screw diameter has an influence on the required driving power. This has already been noted by Rong [6] und Blomeyer [4]. In order to assess the general influence of the parameter, the results of a locally weighted regression is graphically presented in picture 9.

Pic. 8: Model fitting for the coefficient of velocity
Like in the coefficient of velocity, the rotation speed $n$, in the diagram above left, has a great influence. A power function, altogether presenting a positive correlation, can be seen. The influence is weak in the area of approx. $n = 3.5 \, \text{1/s}$ and $5.5 \, \text{1/s}$. For the inclination angle $\beta$ there is initially a linear positive correlation, which increasingly lessens. Initially the influence of the filling level $\phi$, pictures above right is negative. This influence disappears from values of approx. $\phi = 0.4$ onwards. The bulk material parameters that are presented in the lower line of picture 9 reveal the following correlations. However it should be noted that only certain combinations of the 3 parameters that describe the bulk material, are possible. Therefore the influence of all three parameters on the coefficient of power $\lambda$ has to be considered. Nevertheless, since the influence of the bulk material should be simplified and described through these parameters, they are reviewed individually in the following. In case of the bulk density the influence initially increases, but after a maximum of approx. $\rho = 740 \, \text{kg/m}^3$ it sinks again. Altogether the friction coefficient against the screw pitch and tube has a positive influence, which initially is very weak and becomes stronger from a value of approx. $\mu_s = 0.35$. The correlation of the inner friction coefficient $\mu_i$ is similar. The initially very weak negative influence becomes clearly positive from a value of $\mu_i = 0.60$.

After having analyzed the influences on the coefficient of power, the last needed step is finding the simplest formula of correlations, in order to simply and reliably calculate the coefficient of power from the mentioned parameters.

**Summary**

The project to determine guidelines for dimensioning and layout of highly inclined screw conveyors examines the conveyance of bulk material in screw conveyors that are operated with high speed and filling levels, in at inclinations between $20^\circ$ and $60^\circ$. The goal is to develop simple, practical and safe methods to calculate the achievable volume flow and the needed driving power.

While the predetermined of the kinetic behaviour and therefore the possible volume flow is possible with analytical
calculation methods, the calculation of the drive power is not accessible with an analytical observation. Effects such as entrapment or destruction of good in the gap between screw pitch and tube, which significantly increase the energy demands for conveyance, are too manifold to be captured with analytical observations. Therefore, like in other operation areas of screw conveyors (horizontal to slightly inclined and vertical), the determination of the calculation guidelines calls for semi-empirical methods to picture processes that are difficult to capture within the layout method.

The basis for a semi-empirical method is an analytical base approach, which is expanded by one or several empirically determined parameters. The empirical parameters reflect the influences that cannot be captured analytically, subjected to the known parameters. As principle formulas for the two parameters, reviewed within the framework of this project, volume flow and drive power, the formulas known from DIN 15262 [5] are used, and are correspondingly adapted based on theoretical test done in previous projects.

In order to reliably determine the empirical parameters for the entire application area, a sufficient amount of data sets for the parameters is needed. The needed datasets are generated with three different methods: Experimental tests in a large-scale plant, simulations according to the discrete elements method and calculation with numerical methods, which were developed in preceding projects. Through this division of data gathering to different methods it is possible to document all areas of the application area with data sets.

The obtained data sets are examined in detail with statistical methods. In an initial step the influences of the individual parameters are interpreted descriptively with regard to the type of their influence. Building on this, the second step incorporates these insights into the models for empirical parameters, which are determined through regression calculations. The results are simple formulas, which describe the correlations of the influencing factors on the parameters and allow for a reliable forecast. Together with the analytical base approach it is possible to calculate the possible volume flow and the needed drive power.

Bibliography

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<td>g</td>
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<td>D</td>
<td>[m]</td>
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<td>i</td>
<td>[-]</td>
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<td>[N]</td>
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<td>n</td>
<td>[1/s]</td>
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<td>H</td>
<td>[m]</td>
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<td>ν_ax</td>
<td>[m/s]</td>
<td>Axial velocity of material</td>
</tr>
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<td>IV</td>
<td>[m³/s]</td>
<td>Volume flow</td>
<td>ν_G</td>
<td>[m/s]</td>
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<td>l_rect</td>
<td>[A]</td>
<td>Received active current</td>
<td>β</td>
<td>[-]</td>
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</tr>
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<td>L</td>
<td>[m]</td>
<td>Coveying length</td>
<td>ζ</td>
<td>[-]</td>
<td>Coefficient of velocity</td>
</tr>
<tr>
<td>P</td>
<td>[W]</td>
<td>(Conveying-)power</td>
<td>ζ*</td>
<td>[-]</td>
<td>Empirical / Simulated / Determined Coefficient of velocity</td>
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<tr>
<td>MQF</td>
<td>[-]</td>
<td>Mean square error</td>
<td>η</td>
<td>[-]</td>
<td>Motor- and gear efficiency</td>
</tr>
<tr>
<td>P_lift</td>
<td>[W]</td>
<td>Lifting power</td>
<td>λ</td>
<td>[-]</td>
<td>Progress Resistance coefficient / coefficient of power</td>
</tr>
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<td>P_lev</td>
<td>[W]</td>
<td>Idling drive power</td>
<td>λ*</td>
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<td>[W]</td>
<td>(Fictitious) Total friction power</td>
<td>λ_h</td>
<td>[-]</td>
<td>Progress Resistance coefficient for horizontal and slightly inclined screw conveyors</td>
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<td>S</td>
<td>[m]</td>
<td>Screw pitch</td>
<td>μ_s</td>
<td>[-]</td>
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<td>[U]</td>
<td>Effective voltage</td>
<td>μ_i</td>
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<td>Inner friction coefficient of bulk material</td>
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<td>a</td>
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<td>Acceleration</td>
<td>ρ</td>
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<tr>
<td>d</td>
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<td>ϕ</td>
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<tr>
<td>g</td>
<td>[m/s²]</td>
<td>Gravitational acceleration</td>
<td>ωG</td>
<td>[1/s]</td>
<td>Angular velocity of material</td>
</tr>
</tbody>
</table>
Comparison of various ship-unloading equipment for bulk materials concerning their specific energy consumption per ton

The relevance of hard coal as a primary energy carrier

As Fig. 1 shows, today hard coal is still the most important primary energy carrier after crude oil. If you believe international experts the demand for hard coal will grow much faster than that for oil in the next 20 years, with the effect that the consumption will almost double in the same period.

The economic performance of the worldwide steel and electricity industry is to an extremely high degree dependent on the extraction and the import of basic commodities like hard coal or iron ore.

If you take Europe, and especially Germany, as an example, where a considerable amount of hard coal is needed for the production of steel and electricity, underground mining is economically unviable everywhere in Europe due to the cheap coal prices on the global market.

As a result, many of the local coal mines were closed. Indeed, there are a few mines that survived, supported by German subsidies, but no doubt even these mines will be closed when subsidies end in 2018.

As the European demand for the coal has not seriously decreased in the comparison period, the European Union (EU) is in dire need of imports from coal-producing countries. Fig. 2 shows this correlation using the example of all German non-renewable energy resources.
Global resources, reserves and production

In a worldwide comparison of the energy supply the biggest reserves and resources were shown for hard coal. If you consider consumption, in 2008 coal was the second most important primary energy source after oil, which comprises 29% of demand (hard coal 27%, lignite 2%). In the electricity industry, coal was the most important energy source, comprising 41% of demand [2]. The world coal extraction reached about 6.799 Mt. in 2008, from which the biggest share was hard coal (5.733 Mt., 85%) and the remaining 1.025 Mt. (15%) was lignite.

As every economy tries to improve the security of its energy supplies, the questions are:

- Will the most important non-renewable energy carriers be able to satisfy the worldwide growing demand?
- Which ones will be the most reliable in the long run?

The answer is given in Fig. 3, which compares the cumulated consumption of the next 20 years with the actual known reserves and resources.

Fig. 4 shows the same correlation in even more detail and offers no doubt that, compared to conventional oil, there are still inexhaustible resources of coal that can supply humankind for another 1,000 years with affordable energy.

![Fig. 2: Energy Consumption and Imports of Germany in 1998 and 2008](Sources: AGEB 2009, BGR database)

![Fig. 3: Worldwide Supply Situation of Non-Renewable Energy Resources in 2008](IEA 2008)
The regional distribution reserves, resources and the estimated cumulative production of hard coal since 1950 is shown in Fig. 4. North America has the largest remaining hard coal potential, followed by Austral-Asia and the countries of the former Soviet Republic. Regarding hard coal reserves of individual countries, the USA owns the largest volumes in the world (32% of the global share), followed by China (25%), India (11%), Russia (10%), Australia (5%) and Ukraine (4%).

Fig. 4:
(Given in per cent of the total)

Fig. 5:
The three biggest producers of hard coal in 2008 were China (with a global share of 45.8%), followed by the USA (17.2%) and India (8.5%). While China and India extended their production by 7%, it increased only by 3% in the United States.

With a total volume of 930 Mt., about 16% of the global hard coal production was actually traded. About 839 Mt. (90%) of the trading volume was handled by ship [2].

Australia dominated the export market with a total volume of 259.8 Mt. (28%) followed by Indonesia with 202.6 Mt. (21.8%) and Russia with 97.9 Mt. (10.5%).

The three largest importers of coal have been Japan, South Korea and Taiwan. In total volume these Asian countries together import 351.7 Mt. (37.8 %) followed by India with 59.8 Mt. (6.4%), Germany with 44 Mt. (4.7 %), Great Britain with 43.9 Mt. (4.7%) and China with 40.8 Mt. (4.4%).

Environmental aspects

If you compare coal with other non–renewable resources, it has the greatest geological availability. Besides other aspects, the deposits are less concentrated on certain regions and therefore the production is spread across many countries and companies. This ensures a cheap availability for decades and for that reason it is quite possible that there will be a continued strong demand for coal, especially for the Asian markets and even worldwide, as Fig. 1 shows.

A frequently discussed issue at the moment are the emissions that occur during the combustion process. Meanwhile, many industrial installations like power plants and steelworks have modern filter techniques available that avoid the emission of combustion residues like sulphur dioxide and ash. Therefore, modern coal-burning plants can reduce emissions and enhance energy efficiency. A remaining problem is that the emission of the greenhouse gas CO₂ can not be reduced so far and unfortunately coal is the fossil energy resource with the highest specific level of CO₂ emissions. Indeed there are experimental plants that can separate carbon dioxide from the flue gas and liquefy it (Carbon Capture and Storage (CSS)) but on the one hand, the process runs at the expense of efficiency and on the other hand, the search for an adequate final storage solution is difficult and antagonizes the residents nearby. Another problem concerning the power generation is the dimension of coal-burning plants. When futurologists describe a smart grid, they are discussing the designs of a network that consists of many different generators and consumers, who supply each other according to their requirements. Therefore it is essential that the generators in the network have a high flexibility and can reduce their output or can even be turned off when windy weather increases the output of wind turbines.

The circumstances mentioned above could create a lower demand for coal in producing electricity than shown in Fig. 1, but at present it is difficult to imagine how the future energy demand of the world can be met without coal.

Research project

Although there is less exploitation of resources in European coal mines, the industry consumption is not decreasing. Besides, there are a lot of ongoing projects planned for coal-burning power plants and the turnover of port operations that import coal has been increasing for years. Against the background of rising energy costs and for ecological reasons, the aspect of the specific energy consumption of ship-unloading equipment is becoming more important.

Typical bulk unloading equipment

For the handling of bulk materials like iron-ore or coal, there are two completely different kinds of technologies: the continuous and the discontinuous respectively grab-type way. Fig. 6 shows the different types of ship unloaders classified according to the established technology.

For the bulk material coal, the following unloading equipment can be found at larger port operations:

- Grab-Type Unloader
- Vertical Screw
- Bucket Elevator
Due to the completely different technologies involved, there are various pros and cons to the different unloading systems. Besides the specific energy consumption levels, many different properties have to be considered before investing in a new unloader.

**Measurement technique**

The aim of the research project was to determine the specific energy consumption of different types of ship unloaders. Many systems have an electricity meter and a belt weigher on board to determine the required values, but to consider the consumption of single driving units, portable power meters are needed.

Two different measuring techniques are adequate to determine the power in AC and DC systems:

**The three wattmeter method:**

With the three wattmeter method, it is quite simple to determine the accurate power consumption as you can measure the real power in each single phase, as shown in Fig. 8, and you will get the instantaneous real power of the system by adding up the values of the single meters. To calculate the total power consumption, you have to add up the measured means of the time slices over the period under consideration, as shown in the following formulas [4]:

\[ p(t) = u_{1N} \cdot i_1 + u_{2N} \cdot i_2 + u_{3N} \cdot i_3 \]  \hspace{1cm} (1)

\[ W = \int p(t) dt \]  \hspace{1cm} (2)
The single wattmeter method (single phase):

In three-phase systems, the single wattmeter method only gives correct results with balanced loading of the phases, as for example at driving units, and it is important to know or determine the power factor \( \cos \phi \), as shown in the following term:

\[
p(t) = 3 \cdot u_i \cdot i_i \cdot \cos \phi \quad (3)
\]

Modern measurement equipment combines the described methods in a single meter and is furthermore suitable for measuring in AC and DC systems.

In scope of this research project, two different types of power meters were used and can be seen in Fig. 9. On the right side, a fluke 1735 power logger is shown that is suitable for the three wattmeter method. On the right sight is an LEM Analyst 2060 that is suitable for the one wattmeter method. Both meters have a data memory so that values can be logged over a certain period of time.

Measurements at unloading installations

In the following the example of a gantry crane will show the recurring analysis of the unloading devices, especially what values can be measured and what conclusions can be made.

Fig. 10 shows a detail drawing of the considered crane. The drawing shows the typical installation of a gantry crane with a cable trolley. The main drives with closure, godet and trolley unit are direct current motors. Both drives of the lifting unit have an available power of 490 kW; the trolley drive has 250 kW. Besides these main drives, there are the usual auxiliary consumers like carriage drives, boom lifting drive, lights, etc. The following table shows the key data of the unloading device.

![Fig. 11: Technical data of the gantry crane](image)

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Krupp</th>
</tr>
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<tr>
<td>Year of construction</td>
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<tr>
<td>Lifting capacity</td>
<td>35 t</td>
</tr>
<tr>
<td>Grab weight</td>
<td>12 t (19 m³)</td>
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<tr>
<td>Lift above pear</td>
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<td>Horizontal. drive</td>
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<tr>
<td>Flow rate max.</td>
<td>ca. 1,200 l/h</td>
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<td>Flow rate avg.</td>
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<tr>
<td>Installed power</td>
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<td>Personnel placement</td>
<td>2+2</td>
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<tr>
<td>Self-weight</td>
<td>ca. 1,000 t</td>
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</tbody>
</table>
**Fig. 10:**
Detail drawing of a gantry crane

**Fig. 12:**
Power/power consumption diagram of the godet unit drive
Results of the measurement

Fig. 12 shows a diagram of the power and power consumption measurement of the crane's godet unit. You can identify easily different phases of the unloading process. From 12:00 to 12:30, for example, the power level of the unit was reduced because the crane had to clean up the hatch and so the grab was only half-full. After that, the crane changed the hatch and you see amplitudes up to the maximum power of the engine. After a short break at 13:35, the crane driver changed. The negative values occur when the opened grab is lowered into the hatch and the engine is used for dynamic braking. As this installation had no energetic recovery system, the resulting energy was abolished in resistors.

Fig. 13 shows the power and the power consumption of the cranes closure unit. If you compare the diagram with Fig. 12, you can recognise the same unloading phases. The only difference is that the peaks are slightly higher due to the fact that the applied force of the closure unit has to be higher than that of the godet unit to keep the grab closed. Additionally, the negative values are far lower than with the closure unit, due to the fact that the grab is lowered opened.

Fig. 14 shows the power and the power consumption of the trolley drive unit. The peaks of the power are quite independent of the unloading process phases as the horizontal movement is more or less the same. Only after the change of the driver at about 13:35 are the peaks slightly higher.

Fig. 15 shows the results of the energy consumption check of the crane. The specific consumption is quite low with a value of 0.27 kWh/t and it could be even lower if the operator would invest in an energy recovery system, as the potential energy recovery due to dynamic breaking is 0.04 kWh/t. As expected, the total share of the closure unit is clearly higher than that of the godet unit due to corrections in grabbing the coal and the fact that the cable force has to be higher to keep the grab closed. The share of other types of consumption is, with over 30%, quite high due to many other consumers like, for example, a belt conveyor that pulls the material sideways out of the crane.
Summary and conclusions

Fig. 16 shows a comparison of the specific energy consumption of all ship unloaders that were scope of the survey depending on their nominal capacity.

As a first result it can be said that all measured grab unloaders range from 0.2 to 0.4 kWh/t. Due to the energy-incentive principle of conveying, the only screw unloader in this survey has the highest specific energy consumption. The bucket elevator unloaders lie in the middle. That is amazing, as we expected them to be the most economical.

Overall it has to be said that many factors have a big influence in the valuation of the suitability of a unloading device. For example, the higher the installed capacity of an unloader, the higher the costs for the electrical connection; the higher the weight, the higher the civil costs for the jetty. But especially when

the energy consumption is not only a matter of costs, more importance should be attached to it, for example for ecological reasons.

So far the database is too small to give a complete overview, but it is planned to expand the number of measured unloading devices in the future, so that an even more precise conclusion will be possible.
Dipl.-Ing. Christoph Tilke

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Bibliography

Acoustic emission of belt conveyor systems and stockyard equipment used to handle bulk goods, its advanced calculation and noise reduction measures

The increasing capacity of material handling plants, going hand in hand with the spatial approach of settled areas to industrial zones, inevitably leads to the residents’ demand for the reduction of noise pollution. That is a challenge to be taken up by both the operator and the manufacturer of plants like that. It means that those involved have to realize the conceptual characteristics and the physical contents associated with them. Moreover, it is necessary to become intensively familiar with sound-specific levels and their order of magnitude, to be capable of taking a view of demands with respect to emissions. Since a theoretical advanced calculation alone is not sufficient the manufacturers must acoustically measure plants they already built, in order to detect the absolute sound levels, and to enable the efficiency of different noise control measures to be analyzed.

Sound

Sound is a mechanical vibration in gases, fluids and solids. These vibrations propagate at a speed that is specific to the respective medium, the speed of sound. It concludes from this that the sound, in contrast to electromagnetic waves, requires a carrier medium to be propagated.

Sound waves with purely harmonic motion are called tone. If the sound is composed of several tones, ideally of the integral multiple of a basic frequency, there will be talk of harmonic sound. A mix of many frequencies within a frequency band is called noise (e.g. white or pink noise). If humans find the presence of sound a nuisance, a disturbance or even damage, there will be talk of noise.

The Problem

The problem can be described, as follows. A machine makes noises. The noise source is also called place or point of emission. The noise is transmitted on the transmission path from the emission point to the immission place, where certain sound pressure levels must not be exceeded for reasons whatever they are called.

Sound pressure p

Sound pressure p is the compression load that is superposed on the atmospheric pressure during propagation of the sound wave. It is, as effective pressure, expressed in N/m². The so-called airborne sound is a transient pressure that is superposed on the relative, static air pressure. This transient pressure is propagated in the form of longitudinal waves. Because of the wave character it comes to reflections, diffraction- and interference phenomena. The sound pressure is a field size and, as force, it is defined per unit of area.
Sound power $P$

Sound power $P$ is the acoustic power that is delivered by a vibrating element as airborne sound. It is expressed in Nm/s or W. The sound power is, by analogy to the power known in the physics, a relative quantity that is not able to be measured directly.

The sound power $P$ is an emission quantity of a plant, a machine or a component. It can only be indirectly determined by measuring a field size. To analyze the sound power, there are available the sound ranging methods.

The sound ranging can take place in a dead room, in a free field or in a live room while taking into account the environmental conditions.

Another possibility of sound ranging is the metering of the sound intensity on a measuring surface round the object while eliminating the environmental influences to a certain degree.

The mathematical link between sound pressure, sound intensity and sound power is described following the definitions speed of sound, sound particle velocity and their effective values.

Link between sound pressure and sound power

The link between sound pressure and sound power is the most important base to be able to understand acoustics. The sound power is not directly measurable, as already mentioned before, but it is to be fixed by measuring the sound pressure. While doing so, there is to be indicated, among the pressure, the measuring point as well (distance from source).

This shows the often cited analogy to the thermal output of a source that is not directly measurable. Through measurement of temperature at a place in a defined position towards the source it is enabled the thermal output of a body to be determined.

It is of importance to be always aware of the conditions for the validity of the link, derived in the following. We are working on the assumption that it is a homogeneous source, isotropically radiating in an otherwise isotropic room. Both conditions are only fulfilled in special cases. The error resulting from the condition fixed by our end, however, is negligible as long as we only need a „good estimation“. All further reflections on this topic are further based on the incoherence of the sources.

Speed of sound or sound velocity $c$

Speed of sound or sound velocity $c$ is the speed at which the sound waves propagate. It is to set apart from the sound particle velocity. By way of illustration, the wave motion is represented in figure 1.01. Each point may be a gas molecule (air particle). The particle itself effects a harmonic vibration round its neutral position (vertical lines A – M). Due to excursion neighbouring particles get expelled from their neutral position, and they also effect, to the neighbouring particle, a phase-shifted, harmonic vibration round this neutral position. That is how the wave propagation (blue line) is created. The gradient of the straight line is a measure for the sound velocity.

![Fig. 2: Überlagerung Schalldruck und Atmosphärnedruck](image-url)
The particles reciprocate within the sound field. In still air, the particle motion takes place round a neutral position, as already said before. In moving air, the alternating speed caused by the sound field is superposed on the average flow velocity. The phase velocity (speed of sound c) is to clearly set apart from the particle velocity (sound particle velocity v). The sound velocity (= speed of sound) is dependent on the carrier medium.

**Sound particle velocity v**

In a plane sound wave, the link between sound pressure and sound particle velocity is, as follows:

\[ p = \rho \cdot c \cdot v \]

\[ \rho_{\text{Luft}} = 1.2 \, \frac{\text{kg}}{\text{m}^3} \]

\[ p = \text{Schalldruck} \left[ \frac{N}{m^2} \right] \]

\[ \rho = \text{Dichte} \left[ \frac{\text{kg}}{\text{m}^3} \right] \]

\[ c_{\text{Luft}} = 344 \, \frac{\text{m}}{\text{s}} \]

\[ c = \text{Schallgeschwindigkeit} \left[ \frac{\text{m}}{\text{s}} \right] \]

\[ v = \text{Schallschnelle} \left[ \frac{\text{m}}{\text{s}} \right] \]

The product resulting from density and speed of sound is defined as characteristic acoustic impedance.

\[ \rho_{\text{Luft}} \cdot c_{\text{Luft}} = 1.2 \, \frac{\text{kg}}{\text{m}^3} \cdot 344 \, \frac{\text{m}}{\text{s}} = 413 \, \frac{\text{kg}}{\text{m}^2 \cdot \text{s}} \]

\[ \rho_{\text{Luft}} \cdot c_{\text{Luft}} \Rightarrow \frac{\text{kg}}{\text{m}^2 \cdot \text{s}} \Rightarrow \frac{\text{Ns}}{\text{m}^3} \]

**Effective value**

For numerical value data of the field sizes sound pressure and sound particle velocity, there is used the effective value, unless otherwise stated. The effective value of a field size is obtained by squaring the time function, by integrating the latter for a long time, by taking the time mean then, and by extracting the square root at the end.

\[ \tilde{p} = \sqrt{\frac{1}{T} \int p^2(t)dt} \]

When reflecting on vibrations and waves, harmonic motions are of particular importance. Harmonic motions have a sinusoidal variation in time. All vibrations can be decomposed in harmonic motions by Fourier analysis. To a sinusoidal variation of the field size applies:

\[ \tilde{p} = \frac{1}{\sqrt{2}} \cdot p_{\text{max}} \]

**Sound intensity**

The sound intensity I describes the sound power (energy), passing per time unit a surface that is standing at right angles to radiation. The sound intensity is a vector quantity.

\[ \tilde{I} = p \cdot \vec{v} = \frac{p}{A} \cdot \vec{n} \]
Field size, energy size

Field sizes are in the physical sense values that belong to each point in a room. This classification is clear and constant. In contrast to the field sizes, energy sizes do not belong to points in a room, but they apply to the whole room.

Free field

The term free field means a sound field in which all points in a room are only stimulated into vibrations by the sound energy starting at the source. In the free field, there are no reflections or superpositions of sources of sound.

<table>
<thead>
<tr>
<th>Medium</th>
<th>Speed of sound</th>
<th>Remark</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas</td>
<td>$c = \sqrt{\frac{k \cdot R \cdot T}{\rho}}$</td>
<td>$k$=Adiabat exponent $n_1=1.4$ $R$=Gas constant $R_d=287 \cdot \frac{J}{kg \cdot K}$ $T=Temperature[K]$</td>
<td>Air: 332m/s CO2: 260m/s H2: 1258m/s He:964m/s H2O- Steam: 478m/s Natural gas: 400m/s</td>
</tr>
<tr>
<td>Fluids</td>
<td>$c = \sqrt{\frac{K}{\rho}}$</td>
<td>$K$=Bulk modulus</td>
<td>H2O: 1449m/s Hg: 1480m/s Crude oil: 1300…1500m/s</td>
</tr>
<tr>
<td>Solid-state</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>extension waves</td>
<td>$c = \sqrt{\frac{E}{\rho}}$</td>
<td>$E$=Elastic modulus</td>
<td>Steel: Bar-type structure: 5170m/s</td>
</tr>
</tbody>
</table>
| longitudinal       | $c = \sqrt{\frac{E}{\rho} \cdot \frac{(1-\mu)}{(1+\mu) 
(1-2\mu)}}$ | $\mu$=Poisson’s ratio 0.1…0.4 for all media | Steel: solid structure: 5970m/s |
| transverse waves   | $c = \sqrt{\frac{E}{2 \cdot \rho (1+\mu)}}$ | | |
| shear waves        | $c = \sqrt{\frac{G}{\rho}}$ | $G$=Shear modulus | Steel: 3210m/s |

**Table 1:**

| Speed of sound of different carrier media |

<table>
<thead>
<tr>
<th>Schalldruck</th>
<th>Schallschnelle</th>
<th>Schallauslenkung</th>
<th>el. Spannung</th>
<th>el. Stromstärke</th>
<th>el. Widerstand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rez. Abstandsgesetz $1/r$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Schallintensität</th>
<th>Schallenergie</th>
<th>Schalleistung</th>
<th>el. Leistung</th>
<th>mech. Leistung</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rez. Quadratgesetz $1/r^2$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 2:**

| Field sizes and energy sizes |
The Decibel

Experience has shown that having to do with levels and comparative values is not easy at first. The term level means the logarithmic relationship to two sizes, characterized by adding dB to the numerical value. The dB must not be understood as a unit of a quantity. In case of absolute levels, the reference value must always be indicated, provided that it is not supposed to be known.

By using the decibel, one takes the experience into account that the sensation strength of man is not proportional to the stimulus intensity. According to the Weber-Fechner law, only a tenfold stimulus intensity \( R \) leads to a doubling of the sensation strength \( E \).

\[ \Delta E = 10 \log \left( \frac{R}{R_i} \right) \]

The airborne sound reaching the human ear is audible, if the threshold of audibility will be exceeded. The human ears are frequency- and amplitude-selective, and it should be added that frequency and amplitude are in context with each other, as can be seen from the diagram. The human ears are able to register frequencies lying between 16Hz and 20kHz. The lower threshold of audibility of a 1kHz-tone is at a pressure of 0,00002 Pa.

Another strong argument in favour of using levels is the large bandwidth when it comes to sound pressure levels reaching from 2 \( \mu \)Pa to more than 1kPa.

<table>
<thead>
<tr>
<th>Situation bzw. Schallquelle</th>
<th>Entfernung von Schallquelle bzw. Messort</th>
<th>Schalldruck ( p ) in Pascal</th>
<th>unbeantworteter Schalldruckpegel ( L_p ) in Decibel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Düsenflugzeug</td>
<td>30 m</td>
<td>630 Pa</td>
<td>150 dB</td>
</tr>
<tr>
<td>Gewehrechse</td>
<td>1 m</td>
<td>200 Pa</td>
<td>140 dB</td>
</tr>
<tr>
<td>Schmerzwelle</td>
<td>am Chr</td>
<td>100 Pa</td>
<td>134 dB</td>
</tr>
<tr>
<td>Gehörschäden bei kurzfristiger Einwirkung</td>
<td>am Chr</td>
<td>ab 20 Pa</td>
<td>120 dB</td>
</tr>
<tr>
<td>Kampfflugzeug</td>
<td>100 m</td>
<td>6,3 - 200 Pa</td>
<td>110 - 140 dB</td>
</tr>
<tr>
<td>Presluftermutter / Diskothek</td>
<td>1 m / am Chr</td>
<td>2 Pa</td>
<td>100 dB</td>
</tr>
<tr>
<td>Gehörschäden bei langfristiger Einwirkung</td>
<td>am Chr</td>
<td>ab 0,36 Pa</td>
<td>85 dB</td>
</tr>
<tr>
<td>Hauptverkehrsstraße</td>
<td>10 m</td>
<td>0,2 - 0,63 Pa</td>
<td>80 - 90 dB</td>
</tr>
<tr>
<td>PKW</td>
<td>10 m</td>
<td>0,02 - 0,2 Pa</td>
<td>60 - 80 dB</td>
</tr>
<tr>
<td>Fernseher auf Zimmerlautstärke</td>
<td>1 m</td>
<td>0,02 Pa</td>
<td>ca. 60 dB</td>
</tr>
<tr>
<td>Sprechender Mensch (normale Unterhaltung)</td>
<td>1 m</td>
<td>( 2 \cdot 10^{-3} ) - ( 6,3 \cdot 10^{-5} ) Pa</td>
<td>40 - 60 dB</td>
</tr>
<tr>
<td>Sehr ruhiges Zimmer</td>
<td>am Chr</td>
<td>( 2 \cdot 10^{-4} ) - ( 6,3 \cdot 10^{-6} ) Pa</td>
<td>20 - 30 dB</td>
</tr>
<tr>
<td>Blätterauschen, ruhiges Atmen</td>
<td>am Chr</td>
<td>6,32 ( \cdot 10^{-5} ) Pa</td>
<td>10 dB</td>
</tr>
<tr>
<td>Hörschwelle bei 2 kHz</td>
<td>am Chr</td>
<td>( 2 \cdot 10^{-5} ) Pa (20 ( \mu )Pa)</td>
<td>0 dB</td>
</tr>
</tbody>
</table>
Definition of the most important sound levels

Sound pressure level \( L_p \)

The sound pressure level is defined as the twentyfold decade logarithm of the ratio that results from the effective value of the sound pressure and the reference sound pressure. The reference sound pressure is, as already mentioned, defined as \( p_0 = 0.00002 \, \text{Pa} = 20 \, \mu\text{Pa} \).

\[
L_p = 20 \times \log \left( \frac{P}{p_0} \right) \quad \text{in} \quad \text{dB} \quad \text{with} \quad p_0 = 0.00002 \, \text{Pa} \quad \text{and} \quad P \, \text{[Pa]}
\]

\[
p = 0.00002 \times 10^{\frac{L_p}{20}}
\]

The sound pressure level is a measurand, always to be indicated with the distance from the source of sound.

Sound power level \( L_W \)

The sound power level is defined as the tenfold decade logarithm of the ratio that results from the sound power and the reference sound power. As reference sound power is fixed \( P_0 = 10^{-12} \, \text{W} = 1 \, \text{pW} \). The reference value of the sound power results from the reference sound pressure according to

\[
P_0 = \frac{p_0^2}{\rho \times c} = \left( \frac{2 \times 10^{-5}}{4 \times 10^2} \right) \times 1 \, \text{m}^2 = 10^{-12} \, \text{W}
\]

\[
L_W = 10 \times \log \left( \frac{P}{P_0} \right) \quad \text{in} \quad \text{dB} \quad \text{with} \quad P_0 = 10^{-12} \, \text{W} \quad \text{and} \quad P \, \text{[W]}
\]

The sound power level is often used to describe by means of only one numerical value the sound produced by a machine or a plant. At this point, it has to be pointed out that the difference between sound pressure level and sound power level must be absolutely clear. The indication of the sound pressure level requires the indication of the distance from the test object too.

Calculation by using levels

Having to do with levels and comparative values in dB is not easy at first. But after some time it will become a habit with them, because dealing with levels is very simple and has certain advantages, provided that the range of levels is not exceeded. It is only the conversion in absolute pressures and powers that requires the knowledge of logarithmic laws. Equal, relative changes in dB get always expressed by equal dB-differences

\[
\log_a (x \cdot y) = \log_a x + \log_a y \\
\log_a \frac{x}{y} = \log_a x - \log_a y \\
\log_a x^n = n \cdot \log_a x
\]

Energetic linkage of levels with equal reference value

The addition or the separation of different sound portions from each other must on principle take place by intensities, powers or energies that belong to them. For it we make a distinction between the following operations:

- Energetic addition of levels
- Energetic averaging of levels
- Energetic subtraction of levels

The applications in which we are interested are:

- the addition of several sources of sound to which a measuring point is exposed simultaneously,
- the addition of several measuring points on an enveloping surface to determine the sound power of a source of sound, and
- the addition via the frequency to enable the third-octave spectrum to be converted into the octave spectrum, or to calculate the total sound level resulting from the frequency spectrum.

The addition via time to form the averaging- or rating sound level and the sound exposition level are not of interest here. The sound level meters common today automatically form the average value of time and register the bar maximum value within the averaging period of time.

\[
\text{Summenpegel} \quad L_s = 10 \times \log \left( \sum_{i=1}^{n} 10^{\frac{L_i}{10}} \right)
\]

\[
\text{Mittelungspegel} \quad L_m = 10 \times \log \left( \frac{1}{n} \sum_{i=1}^{n} 10^{\frac{L_i}{10}} \right) \Rightarrow L_m = L_s - 10 \times \log n
\]
Enveloping surface, enveloping surface dimension

The link between the energy size (sound power level) and the field size (sound pressure level) is established by the enveloping surface. According to DIN 45635 the sound power level is determined by the enveloping surface method. To this end the average sound pressure level is taken, at appropriate distance, on a measuring surface enveloping the machine (enveloping surface). As enveloping surfaces are possible simple geometric forms like balls, cylinders, cuboids.

The mostly common enveloping surfaces in the plant engineering are cuboids, cylinders and balls or parts of them. The indication of the position and the distance from the test object is an essential part when measuring the sound pressure.

The measuring surface $S$, or better the enveloping surface, is the surface in [m²] enveloping the test object and resulting from the measuring distance. The enveloping surface dimension is defined as the tenfold decade logarithm of the ratio that the enveloping surface bears to the reference surface of 1m². Here, it may be noted that only in case of a hemispherical radiation, where the noise source is in the middle of the ball, no reflections occur on surfaces forming the boundary. The reflections intensify the sound pressure level on the enveloping surface. The sound power of the machine fixed on that basis would be incorrect and needs to be corrected. That is why a measurement to be taken in a dead room or in a free field would be ideal.

\[
L_w = L_p + L_s
\]

\[
L_w = \{10 \times \lg\left(10\sum_{i=1}^{n} \frac{L_p}{S_i}\right)\} + L_s
\]

From this equation can be seen at once that the sound power level for the plant about that is talked here is always higher than the sound pressure level. The sound power level only becomes lower than the sound pressure level, if the quotient resulting from the enveloping surface divided by the reference surface of 1m² will get smaller than 1, because the logarithm will be negatively then. But this goes only for enveloping surfaces that are smaller than 1m², a rare fact in case of equipment used to handle bulk material.

With the help of a small example shall be made clear the yet important link between the three sizes sound pressure level, sound power level and enveloping surface. On the slewing crane, about that is talked in more detail later on, there has been taken, at a distance of 18.5m, a sound pressure level of $L_p = 67.6$ dB. Basing on a hemispherical enveloping surface and on a sound pressure level that is equal over the whole enveloping surface, the sound power of the slewing crane is calculated, as follows:

\[
V = \frac{4}{3} \pi \cdot r^3
\]

\[
A_o = \frac{dV}{dr} = 4 \cdot \pi \cdot r^2
\]

\[
S = \frac{1}{2} A_o = 2 \cdot \pi \cdot r^2 = 2 \cdot \pi \cdot 18.5^2 = 2150 \text{m}^2
\]

From it results, according to definition, an enveloping surface dimension of
Now, it is enabled the sound power level of the slewing crane to be calculated.

\[
L_W = L_P + L_S = 67.6 + 33.3 = 100.9\, dB(A)
\]

### A-weighting

All values have been represented in the form of linear values till now. Because of the dependence on the frequency of the human ears, as shown in figure 4, the linear values are adapted to the frequency selectivity of the ears by means of filters. As a function of the noise source, there is the A, B, C and D-weighting. In general and when rating the noise of cranes too, use is made of the A-weighting. The A-weighted sound levels are characterized by the index A, and on top of that, they get emphasized by an A in brackets, added to the decibel dB(A).

#### Filters (third-octave filters, octave filters)

In the sphere of acoustic metrology, third-octave filters and octave filters proved to be a good instrument for rating the noise spectrum. This type of filters are capable of letting uninfluenced the power part within the bandwidth, but they are able to suppress the remaining spectrum above and below the limit frequency. Both filter types are characterized by the indication of the centre frequency, the bandwidth and the position of the limit frequencies, defined by the standards DIN 45652 and EN ISO 266.

<table>
<thead>
<tr>
<th>Center frequency [Hz]</th>
<th>10</th>
<th>12,5</th>
<th>16</th>
<th>20</th>
<th>25</th>
<th>31,5</th>
<th>40</th>
<th>50</th>
<th>63</th>
<th>80</th>
<th>100</th>
<th>125</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weighting [dB]</td>
<td>-70.4</td>
<td>-63.4</td>
<td>-56.7</td>
<td>-50.5</td>
<td>-44.7</td>
<td>-39.4</td>
<td>-34.5</td>
<td>-30.2</td>
<td>-26.2</td>
<td>-22.5</td>
<td>-19.1</td>
<td>-16.1</td>
</tr>
<tr>
<td>Center frequency [Hz]</td>
<td>150</td>
<td>200</td>
<td>250</td>
<td>315</td>
<td>400</td>
<td>500</td>
<td>630</td>
<td>800</td>
<td>1000</td>
<td>1250</td>
<td>1600</td>
<td>2000</td>
</tr>
<tr>
<td>Weighting [dB]</td>
<td>-13.4</td>
<td>-10.9</td>
<td>-8.6</td>
<td>-6.5</td>
<td>-4.8</td>
<td>-3.2</td>
<td>-1.9</td>
<td>-0.8</td>
<td>0</td>
<td>0.6</td>
<td>1</td>
<td>1.2</td>
</tr>
<tr>
<td>Center frequency [Hz]</td>
<td>2500</td>
<td>3150</td>
<td>4000</td>
<td>5000</td>
<td>6300</td>
<td>8000</td>
<td>10000</td>
<td>12500</td>
<td>16000</td>
<td>20000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weighting [dB]</td>
<td>1.3</td>
<td>1.2</td>
<td>1</td>
<td>0.5</td>
<td>-0.1</td>
<td>-1.1</td>
<td>-2.5</td>
<td>-4.3</td>
<td>-6.6</td>
<td>-9.3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Abb. 6:** Filterkurve A-Bewertung

\[ L_S = 10 \times \lg \left( \frac{S}{S_0} \right) = 10 \times \lg \left( \frac{2150}{1} \right) = 33.3\, dB \]

\[ S_0 = 1\, m^2 \]
The centre frequency of the third-octave and the octave is the square root resulting from the product of both limit frequencies. The upper limit frequency of the octave is twice the lower limit frequency, and the upper limit frequency of the third-octave is $\sqrt{2}$ the lower limit frequency.

When there is talk of these filters, it is about filters of constant, relative bandwidth. On a logarithmic frequency scale, there are the bandwidths always equidistant. The bandwidths of the two filters, however, increase logarithmically when getting plotted in linear frequency scale. That is due to the descending energy content in case of higher frequencies.

### Description of a classic plant

The plant described here is part of a steeped in tradition, very modern steel works with a stockyard for different sorts of coal. The stockyard is served by a stacker and two rail-bound scraper reclaimers. The coal mainly arrives on barges at the port, situated at a distance of 1 km, where unloading of the barges takes place by means of a grab-type ship unloader. Through a pipe conveyor and other belt conveyor systems, the coal is directly transported from the port to the storage bins of the coking plant or the stockyard for getting stored temporarily.

The steel works already exist since 100 years. In the course of this century, the residential areas kept on approaching the steel works. Structural alterations within the steel works must always be aimed at reducing, as far as possible, the annoyance of the residents caused by immissions, but they must not bring about an increase of the latter.

### Table 5: Table centre frequency / Octave filter

<table>
<thead>
<tr>
<th>Centre frequency</th>
<th>Lower transmission frequency</th>
<th>Upper transmission frequency</th>
<th>Bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15,0</td>
<td>11,0</td>
<td>22,0</td>
<td></td>
</tr>
<tr>
<td>31,5</td>
<td>22,0</td>
<td>44,0</td>
<td></td>
</tr>
<tr>
<td>63,0</td>
<td>44,0</td>
<td>88,0</td>
<td></td>
</tr>
<tr>
<td>125,0</td>
<td>88,0</td>
<td>177,0</td>
<td></td>
</tr>
<tr>
<td>250,0</td>
<td>177,0</td>
<td>355,0</td>
<td></td>
</tr>
<tr>
<td>500,0</td>
<td>355,0</td>
<td>710,0</td>
<td></td>
</tr>
<tr>
<td>1000,0</td>
<td>710,0</td>
<td>1420,0</td>
<td></td>
</tr>
<tr>
<td>2000,0</td>
<td>1420,0</td>
<td>2840,0</td>
<td></td>
</tr>
<tr>
<td>4000,0</td>
<td>2840,0</td>
<td>5680,0</td>
<td></td>
</tr>
<tr>
<td>8000,0</td>
<td>5680,0</td>
<td>11360,0</td>
<td></td>
</tr>
<tr>
<td>16000,0</td>
<td>11360,0</td>
<td>22720,0</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 7: Aerial photograph – Steel works Krupp Mannesmann HKM

Zweitgrößtes Stahlwerk in Deutschland mit 5,5 Mio. t Stahlerzeugung

2.4 km² Fläche, 25 km Straßennetz, 78 km Schienennetz

Kokerei

Sinteranlage

Hochofen A

Hochofen B

Stahlwerk

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To improve the quality and to increase the capacity, the coal logistics belonging to the coking plant got newly planned and organized. The stockyard for coal, served by wheel loaders till now, has been equipped with automatically-operated machines and belt conveyor systems.

For being capable of detecting and analyzing the admissible acoustic emission levels, 6 test points have been fixed round the steel works, at the nearest residential areas. Because of the admissible sound immission levels to be kept according to „TA Lärm” and the administration rules being part of it, maximally admissible sound pressure levels have been defined for these measuring points.

### Table 6: Example of admissible sound pressure level at place of immission

<table>
<thead>
<tr>
<th>Test point</th>
<th>Adm. sound pressure level (dB(A))</th>
<th>Space between measuring point and coal stockyard</th>
<th>$L_i$ = $10 \log(2 \cdot x^2)$</th>
<th>Adm. sound power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test point 1</td>
<td>25</td>
<td>1900 m</td>
<td>73,6 dB</td>
<td>98,5 dB</td>
</tr>
<tr>
<td>Test point 2</td>
<td>32</td>
<td>400 m</td>
<td>69,3 dB</td>
<td>91,9 dB</td>
</tr>
<tr>
<td>Test point 3</td>
<td>38</td>
<td>350 m</td>
<td>58,9 dB</td>
<td>96,9 dB</td>
</tr>
<tr>
<td>Test point 4</td>
<td>26</td>
<td>1600 m</td>
<td>72,1 dB</td>
<td>98,1 dB</td>
</tr>
<tr>
<td>Test point 5</td>
<td>25</td>
<td>1200 m</td>
<td>69,6 dB</td>
<td>94,6 dB</td>
</tr>
<tr>
<td>Test point 6</td>
<td>25</td>
<td>2100 m</td>
<td>74,4 dB</td>
<td>99,4 dB</td>
</tr>
</tbody>
</table>

![Fig. 8: Position of test points](image-url)
Having neglected the very complex sound diffusivity, whose treatment requires the use of a specialized software, however, it is enabled the admissible sound power of the new coal logistics to be assessed, even with the aid of simple means.

The sound power levels shown in the table, and calculated on the basis of the admissible sound pressure levels at the places of immission would only be accepted, if the plant could be considered point sound source. But since the individual machines and plant components are spread over a large surface, the influence individual sound sources have on different places of immission is highly varying. That is why the part in the sound pressure the slewing crane in the port has at the place of immission 1 will be far bigger than that at the place of immission 2 or 3. So, the position and distribution of the individual noise sources need to be taken into account when fixing their maximally admissible sound power levels. That is the direct consequence of the closeness of residential areas to the plant. It can be made a rule, as formulated in the VDI 2714 no longer valid today, that an accumulation of noise sources can be considered point sound source then, if the distance from the centre point of the noise sources will be at least twice the diameter of the circle surrounding the noise sources.

Structure of the plant

Let us follow the way of the coal from its arrival at the port by means of pusher barges to the stockyard, and its further transport to the coking plant.

Slewing crane

The slewing crane that is located in the port serves to unload the pusher barges. The coal taken out of the barges by the slewing crane gets discharged into the travelling bin attached to the crane. The bin’s task is to feed the coal on to the discharge belt conveyor uniformly. Moreover, by using trucks and wheel loaders it is possible to create slag dumps on that side of the discharge belt conveyor turned away from the harbour basin, and to have them loaded by the slewing crane into the barges.

As far as the noise emission is concerned, it has been decided that the noises the pusher barges produce as well as the noises resulting from the contact of the grab with the hatch wall or bottom will not slip into the noise balance. These noises, very highly dependent on the crane driver’s experience and skill, did already exist before.

The crane construction is a proven, solid type, mainly consisting of the portal that is arranged parallel to the quay and travelling on rails, the machine house situated over the central column and mounted on the portal through a ball-race slewing connection, as well as the boom. The boom is a latticework construction and rigidly connected to the steel structure of the crane upper section.

The drive units belonging to the lifting-, closing and slewing gears turned out to be the essential noise sources of the crane. Furthermore, it could be found out that the air conditioning systems serving to cool down the E-house represent a further noise source not to be neglected. On the other hand, it is enabled the sound power achieved by the travel drive units to be neglected. A detailed analysis of the crane through airborne noise measurements on the whole crane and on individual units, as well as the

Fig. 9: Plant scheme HKM
<table>
<thead>
<tr>
<th>No.</th>
<th>Source of sound</th>
<th>Pre-req.</th>
<th>$L_{w}$ forecast without action</th>
<th>$L_{w}$ Forecast with action</th>
<th>Measurement after having taken action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Harbour basin with pusher barges</td>
<td>90</td>
<td>306</td>
<td>95</td>
<td>93.4</td>
</tr>
<tr>
<td>2</td>
<td>Slewing crane</td>
<td>90</td>
<td>306</td>
<td>95</td>
<td>93.4</td>
</tr>
<tr>
<td></td>
<td>Drive unit / Lifting and closing gear</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Drive unit / Slewing gear</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Travel drive units</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Air conditioning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Stackhales (for different sorts of coal)</td>
<td>94</td>
<td>302</td>
<td>94</td>
<td>93.8</td>
</tr>
<tr>
<td>4</td>
<td>Discharge belt conveyor (L=485m)</td>
<td>94</td>
<td>302</td>
<td>93</td>
<td>93.8</td>
</tr>
<tr>
<td>5</td>
<td>Transfer station</td>
<td>90</td>
<td>303</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>Drive unit / Discharge belt conveyor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distributor chute</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spillage conveyor</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Magnetic separator</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>6</td>
<td>Pipe conveyor (L=716m)</td>
<td>162</td>
<td>307</td>
<td>102</td>
<td>98.5</td>
</tr>
<tr>
<td>7</td>
<td>Corner station Nord-West</td>
<td>150</td>
<td>306</td>
<td>90</td>
<td>93</td>
</tr>
<tr>
<td></td>
<td>Drive unit / Pipe Conveyor (753kW)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spillage conveyor</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>8</td>
<td>Cross conveyor (L=76m)</td>
<td>87</td>
<td>94</td>
<td>85</td>
<td>81.3</td>
</tr>
<tr>
<td>9</td>
<td>Corner station Nord-Est</td>
<td>90</td>
<td>302</td>
<td>90</td>
<td>93.3</td>
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<td>Drive unit / Cross conveyor (45kW)</td>
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<td>Material flow divider</td>
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<td>10</td>
<td>Stacking belt conveyor (L=237m)</td>
<td>89</td>
<td>300</td>
<td>90</td>
<td>88.8</td>
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<tr>
<td>11</td>
<td>Reclaiming belt conveyor (50m)</td>
<td>86</td>
<td>90</td>
<td>60</td>
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<td>(L=247m)</td>
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<td>91</td>
<td>99</td>
<td>90</td>
<td>89.2</td>
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<tr>
<td>13</td>
<td>Stacker with tripper car</td>
<td>92</td>
<td>99</td>
<td>94</td>
<td>94.9</td>
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<tr>
<td></td>
<td>Stacker belt conveyor (L=137m)</td>
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<tr>
<td></td>
<td>Drive unit / Stacker belt conveyor (554kW)</td>
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<tr>
<td></td>
<td>Travel drive unit (4x5.5kW)</td>
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<td>Air conditioning</td>
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</tr>
<tr>
<td>14</td>
<td>Portal scraper West</td>
<td>97</td>
<td>107</td>
<td>100</td>
<td>99.2</td>
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<tr>
<td></td>
<td>Travel drive unit (6x44kW)</td>
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</tr>
<tr>
<td></td>
<td>Drive unit / Scrapers chain (590kW)</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Boom (L=43m)</td>
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<td></td>
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<td>107</td>
<td>100</td>
<td>99.9</td>
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<td></td>
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<tr>
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<td>Drive unit / Scrapers chain (590kW)</td>
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<td>Boom (L=43m)</td>
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<td></td>
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<td>Air conditioning</td>
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<td>16</td>
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<td>17</td>
<td>Cross conveyor (L=50m)</td>
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<td>79.9</td>
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<td>90</td>
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<td>Drive unit Cross conveyor (55kW)</td>
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<td>Magnetic separator</td>
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</tr>
<tr>
<td></td>
<td>Roller bar grizzly</td>
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</tr>
<tr>
<td></td>
<td>Belt conveyor to collect foreign bodies</td>
<td></td>
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</tr>
<tr>
<td>19</td>
<td>Longitudinal belt conveyor 1 (L=82m)</td>
<td>88</td>
<td>54</td>
<td>85</td>
<td>81.5</td>
</tr>
<tr>
<td>20</td>
<td>Coal crushing plant</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>21</td>
<td>Longitudinal belt conveyor 2 (L=30m)</td>
<td>86</td>
<td>66</td>
<td>86</td>
<td>84.7</td>
</tr>
</tbody>
</table>
measurement of the structure-borne noise through vibration pick-ups on the supporting frame of the lifting gear drive units and on the central column, made in parallel with it, have shown the dominance of the meshing frequency of the input gear taken at approx. 500 Hz within the range of the structure-borne sound formation. The drive motors of the lifting gear proved to be the main source of airborne sound formation. The frequencies of the airborne sound emitted by the motors are 2500 Hz or twice the pulse rate of the frequency converters. The same goes for the slewing drive gears. It is only the meshing frequency of the planetary gearboxes which differs from that one of the bevel wheel gearboxes belonging to the lifting gear.

The aim of the structure-borne sound measurements is to establish the transmission paths of the sound, and to correlate the respective shares with the airborne sound measurements, in order to be able to quantify the shares the individual sources of sound have in the overall noise.

The structure-borne sound of the lifting gear drive units is lead into the crane’s structural steelwork through the floor of the machine house, and its radiation takes place over the large-surface steel structure of the crane’s upper section, including the boom, and the portal that is arranged underneath the machine house. The central column acts as baffle for the structure-borne sound stimulus, transmitted through the slewing drive units and the ball-race slewing connection into the central column.

Actions intended to reduce noise should begin at the noise source, if possible, before taking secondary ones. That is the reason why the gearboxes have been equipped with a noise-optimized tooth. But this action could only contribute to a slight reduction of the sound power of approx. 1.5 dB. So, secondary actions near the noise source needed to be taken. To this end, the drive units belonging to the lifting gear have been fixed on flexible supports to the steel structure. The design of such flexible supports requires particular care to obtain the best possible insulation. An execution while basing on the standard VDI 2062 also requires the keeping of the maximum load factor of Elastomers, given by the manufacturer. The airborne sound emitted by the units get to the outside through the ventilation apertures provided for in the machine house, the opening to enable the rope passage and the hollow central column.

All openings, including that one allowing passage of rope, have been equipped with sound absorbers. The ventilators have been designed in a noise-optimized way, and the plane on which the central column goes outdoors got completely closed by means of sound insulation elements having a sound insulation factor of R=30dB. When designing sound insulation elements, care must be taken that the sound insulation factor given by the manufacturer will not be reached on constructions, as it relates to a single element while taking into account ideal conditions. On constructions consisting of these elements the sound insulation factor to be reached gets reduced to approx. 8 to 15 dB, dependent on the execution and the complexity of the construction. ▶
In the sound spectrum of constructions like that, there are two invasions, namely at the coincident frequency on the one hand, and at the resonant frequency on the other. When it is about the coincident frequency, the wavelength of the airborne sound corresponds to the bending wave of the building component. That is why there is talk of coincidence too. Within the resonant range, the airborne sound frequency corresponds to the natural frequency of the building component.

The final action taken did consist in the cladding, by using sound insulation elements, of the complete structural steelwork involved in the sound radiation. It works quite good on flat building components, but it is difficult to realize on the boom because of its latticework construction.

The sound power of the slewing crane is mainly dependent on the operator and the operation with or without damping of the grab’s reciprocating motion. The noises produced during the unloading of the grab into the bin belong to this category as well, and they can only be reduced by showing the crane operators what to do. For obtaining minimum noises during unloading operation, the grab is to be placed closely over the bin, and in the bin there should always be cushioning material having a damping effect.

The package of measures described before could help to reduce the sound power level from 106 dB(A) to 93.4 dB(A).

Belt bridges

On all belt bridges, it has been decided to class the sound power of the drive units with the corner towers and the transfer stations. That is a good idea in so far as it is enabled the drive units to be considered point sources, whereas the pipe conveyor route, on the other hand, is taken as line sound source. The lengths of the belt bridges installed here do not allow anymore to make a distinction between the influence of the drive unit and the dominant noise produced by the pipe conveyor, already at a distance of 10 to 20 m from the drive unit.

The statements made here do not go for the troughed belt conveyors alone, but especially for the pipe conveyor too. On the pipe conveyors, however, one must be prepared for sound pressure levels getting something higher, because of the narrow curves.

The belt bridges are representing an essential source of sound, because of their big length. But the real noise sources are the belt conveyor idlers that determine the sound power level of the conveyor by their construction and the type of idler supports. Many tests made on comparable belt conveyor systems could furnish proof of the strong scattering of noise emissions.

To be able to deal with line noise sources, one must still form an idea of specific sound power levels. Specific, physical quantities are always relative quantities. The sound power level on linear sources of sound refers to the length of the source. Thus, the specific sound power is the total sound power of a belt conveyor, divided by its length in meters.
The total sound power is inversely calculated on the basis of the specific sound power:
\[ L_W = L_W - 10 \times \log \left( \frac{d_i}{d_j} \right) \]

To convert a known (measured) sound power of a belt conveyor to another belt speed, we apply the following empirical formula:
\[ \Delta L_W = 30 \times \log \left( \frac{v_{n_{\text{new}}}}{v_{n_{\text{old}}}} \right) \]

In accordance with the following diagram, it is enabled the specific sound power level to be derived from the sound pressure measuring by adding the distance.

Many tests made in the last 20 years on belt conveyors we built, where a belt speed of 2.0 m/s has been taken as standard, allow to tell the difference between the following two sound power groups on idlers:

- **quiet idlers** \( L'_{W} = 60 \text{dB(A)/m bis 75 dB(A)/m} \)
- **standard idlers** \( L'_{W} = 70 \text{dB(A)/m bis 80 dB(A)/m} \)

As a function of the highly estimated sound power and the weather conditions, the pipe conveyor has been equipped with a single-layer trapezoidal sheet wall cladding and a single-layer trapezoidal sheet roof, in order to get a shielding in direction of the Rhine river and the test point that is located there.

On the basis of the sound pressure measurements taken along the closed side of the pipe conveyor, there could be calculated a sound power level of \( LWA = 85,2 \text{dB(A)} \), and on the open side, there has been calculated, considering the reflection resulting from the cladding, a sound power level of \( LWA = 98,4 \text{dB(A)} \).

The idlers are considered the main noise source on belt conveyor systems. That is the reason why special attention must be turned to the selection of correct and appropriate idlers. Comparison measurements made on a test carrier have shown that the sound pressure levels taken at a distance of 1m from a belt conveyor system did vary between 68dB(A) and 72dB(A), dependent on idlers of different manufacturers and type.

When use is made of plastic bushes between the idler axle and the idler support, particular attention must be directed towards the electrical conductivity of the bushes within the EX-zone.

Because of the large number of idlers installed, pipe conveyors also emit a higher sound power than comparable troughed belt conveyors. As the pipe conveyor does not require transfer stations, it is enabled the belt bridges to be a tighter type, a fact simplifying actions in the matter of sound insulation. So, the rating of the pipe conveyor is as bad or as good as that of a troughed belt conveyor, seen from a sound-specific point of view.

From the following table can be seen a further, interesting effect. At the start of the pipe conveyor operation, the sound power level taken at the belt route was higher (by 10,3dB(A)) than after an operation of 2 months. The reason is probably a micro-motion of the inner belt edge against the outer belt surface within the lap joint of the belt. Since the maximum level was 2,5kHz, the effect, that could be very strongly noticed, had a considerable influence on
the measuring result, because the A-weighting even gets here maximally. Having treated the belt edge with talcum powder, the noise level did directly sink by the difference of 10.3 dB(A). After an operation of approx. 2 months, and without further treatment with talcum, the sound level get levelled out at $L_w=69.9$ dB(A), and it could sink further in fact.

All belt conveyor drives have sound protection hoods. Nevertheless, the sound power taken at the pipe conveyor drive unit in the corner station North-West exceeded the value planned. That was caused due to the instruction, providing for a mounting of the drive unit on a base plate. This plate was set vibrating by the drive unit, a condition audible and measurable in the form of airborne sound. With a view to reducing the sound, the base plate was put into an off-tuned state by fixing steel cubes to the points exposed to the highest particle velocity.

To determine the positions where the steel cubes have to be welded on, one draws on the discovery made by Ernst Florens Friedrich Chladni at the end of the 18th century, furnishing proof of the fact that it comes to a characteristic spreading of sand, having uniformly sprinkled with sand plates and membrane elements and set into natural vibration then. The sand is carried away from the areas exposed to the highest particle velocity, the bulges, and it accumulates on standing nodal lines and points exposed to lowest particle velocity. The nodal lines are function of the plate form and the type of holder.

If a driving plate is sprinkled with sand and put into operation for some time, it will come to figured effects that are similar to the Chladni's figures. Now, the steel cubes have to be fixed by welding to the points presenting a small quantity of sand.

### Table 8: Time change of the third-octave spectrum of a pipe conveyor

<table>
<thead>
<tr>
<th></th>
<th>63</th>
<th>80</th>
<th>100</th>
<th>125</th>
<th>160</th>
<th>200</th>
<th>250</th>
<th>315</th>
<th>400</th>
<th>500</th>
<th>630</th>
<th>800</th>
<th>1.0 k</th>
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<tbody>
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<td>74.76</td>
<td>65.4</td>
<td>64.4</td>
<td>64.2</td>
<td>63.1</td>
<td>61.1</td>
<td>59.8</td>
<td>58</td>
<td>56.7</td>
<td>57.12</td>
<td>57.09</td>
<td>56</td>
</tr>
<tr>
<td>End</td>
<td>69.9</td>
<td>67.43</td>
<td>66.48</td>
<td>65.75</td>
<td>64.44</td>
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<td>-2.7</td>
</tr>
</tbody>
</table>

Fig. 14: Acoustic off-resonance of a drive frame

Fig. 15: Chladni's figures
The coupling hoods, screw-connected to the same base plate, got uncoupled with the aid of plastic elements. For such hoods, whose primary function consists in a protection against accidental contact, the obvious thing to do would be to use perforated plates or expanded metal or similar instead of solid sheet metal. A perforated portion of 30% makes it already possible to reduce the sound radiation by 80%.

The two actions mentioned before could help to minimize the sound power level of the drive unit from at first \( L_{WA} = 101.9 \text{ dB(A)} \) to \( L_{WA} = 99.2 \text{ dB(A)} \). Thus, the sound power level has almost halved.

### Material flow divider

We follow the coal on its further way and get through the cross conveyor No. 8 to the corner station North-East. This corner station accommodates a material flow divider, enabling the coal to be transported through the feeding belt conveyor No. 10 to the stacker. Or alternatively, to guide the material flow through the reclaiming belt conveyor No. 12 towards the coking plant. The distance between the two belt conveyors and the minimally possible inclination of the chutes, lead to a relatively high minimum fall of the material at the cross conveyor.

Due to the high fall and dependent on the nature of coal (grain size, moisture, etc.) the sound power level produced by the material flow divider experiences a change. On the chutes, there occurs an acoustic pattern, very similar to the white noise, featuring a large bandwidth of frequencies. Because of the equipartition of the energy density for the frequencies, the human ears regard this noise as very unpleasant. The large dimensions of the chute and, consequently, the large enveloping surface result in remarkable sound power levels.

It follows for the material flow divider a total sound power level of:

\[
L_{WF} = 10 \cdot \log\left(10^{10} + 10^{10} + 10^{2.3}\right) = 92.3 \text{ dB(A)}
\]

The dependence of the sound power level on the enveloping surface is made clear with the help of this example. An area with a low sound pressure level at its top can produce a considerably high sound power, provided that the area is sufficiently large. That is a clear demonstration of the analogy to the thermodynamics. A heating unit is able to warm up a room in spite of its low surface temperature. The human can touch the heating unit without getting burnt the fingers. But we cannot touch the match flame whose energy is not sufficient enough to warm up the room.

Possible actions to help to reduce the sound power of the chute are:
Surfaces not directly into contact with the material must get a rubber lining. Surfaces directly into contact with the material are to be lined with solid and thick sheet metal. Cladding by using sound insulation elements. The corner station must be an enclosed type.

Stacker

Tests made on different stackers for coal have shown relatively low sound power levels. Only the stacker belt conveyor and the appertaining drive unit are considered critical. The noise the falling bulk material produces, however, can reach a higher sound power level than the stacker itself. But the sound power the coal obtains should be relatively low thanks to its internal damping property.

Full portal reclaimer

The full portal reclaimer serves to reclaim the coal piles, dependent on the need of the coking plant, created by means of the stacker before. Due to their design and function scraper reclaimers are to be considered critical components, seen from the sound-specific point of view.

The reclaimer portal covers the whole stockpile. On both sides of the stockpile there are laid the track rails. The real handling mechanism is the boom, equipped with a two-strand, endless chain to which the scraper blades are fixed. The boom is a solid web construction.

The reclaimer capacity is function of the lifting- and lowering movements of the boom as well as of the travelling speed. Lowering of the boom takes place in discrete steps, whereas the chain to which the scraper blades are fixed works at constant speed. Because of the known lot of noise portal reclaimers produce during operation (more than LW=110 dB(A)), the sound power level has already been reduced during the design phase by taking the following measures:

- Structure-borne sound insulation of the runner rail of the chain rollers by using elastomers
- Stiffening by welding in pipe pieces into the solid web construction of the boom
- Covering the top side of the boom by using sound-deadening corrugated sheet metal
- Return sprocket made of PA6 to reduce clattering noises.

Noise forcasting (sound power of drive mechanisms)

A first, rough assessment of the sound power levels drive units produce can take place on the basis of the rated power and the nominal speed of motors and gearboxes. To this end, the engineer can rely on the two standards IEC 60034 and VDI 2159. They make it possible for us to assess...
the sound power of all electrical drive units belonging to the machines and the belt conveyor system, and to plan appropriate actions in the matter of sound control.

While doing so, the calculation sequence is the easiest thing in the world. On the basis of the rated power and the speed of the drive unit planned to be installed, the sound power level to be expected of this power group will be taken from the standard IEC 60034-9.

With the help of the gearbox type (bevel wheel gearbox, spur wheel gearbox, bevel and spur wheel gearbox, planetary gearbox) and the calculated, mechanical capacity of the drive unit, it is enabled the sound power expected of the gearbox to be taken from the standard VDI 2159.

The two sound powers are energetically added now. With it we are able to know the sound power level to be expected of the whole drive unit.

With the help of the enveloping surface of the drive unit, and known dimensions, it is possible now, to calculate the sound pressure at every arbitrary distance from the drive unit.

A further, important vibration size is the frequency that must also be known to be capable of dimensioning drive units. Basing on the motor speed it is made possible to calculate the input frequency of the gearbox and, thus, all meshing frequencies.

Since the eighties, gearboxes in Germany and all over the world get tested with a view to their vibration and noise properties. Among the data given by the manufacturers, there have been tested by the Forschungsvereinigung Antriebstechnik hundreds of standard gearboxes and the results get published in the standard VDI 2159. This standard has been issued in 1985 for the first time and it got updated in 1999.

![Fig. 19: Sound power levels of spur wheel gearboxes as per VDI 2159-1985](image)

### Table 10: Sound power levels dependent on rated power and speed (IEC 60034)

<table>
<thead>
<tr>
<th>Design power</th>
<th>0,1</th>
<th>1</th>
<th>10</th>
<th>100</th>
<th>1000</th>
<th>2300</th>
<th>3150</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>77,1</td>
<td>12,3</td>
<td>log(P)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Speed</th>
<th>Design power</th>
<th>Sound power level LWA [dB(A)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>rNS</td>
<td>0.1 - 1.1</td>
<td>12</td>
</tr>
<tr>
<td>rNS</td>
<td>1.1 - 2.2</td>
<td>12</td>
</tr>
<tr>
<td>rNS</td>
<td>2.2 - 5.5</td>
<td>12</td>
</tr>
<tr>
<td>rNS</td>
<td>5.5 - 11.0</td>
<td>12</td>
</tr>
<tr>
<td>rNS</td>
<td>11.0 - 22.0</td>
<td>13</td>
</tr>
<tr>
<td>rNS</td>
<td>22.0 - 55.0</td>
<td>14</td>
</tr>
<tr>
<td>rNS</td>
<td>55.0 - 119.9</td>
<td>14</td>
</tr>
<tr>
<td>rNS</td>
<td>119.9 - 229.9</td>
<td>14</td>
</tr>
<tr>
<td>rNS</td>
<td>229.9 - 553.9</td>
<td>15</td>
</tr>
</tbody>
</table>

Since the eighties, gearboxes in Germany and all over the world get tested with a view to their vibration and noise properties. Among the data given by the manufacturers, there have been tested by the Forschungsvereinigung Antriebstechnik hundreds of standard gearboxes and the results get published in the standard VDI 2159. This standard has been issued in 1985 for the first time and it got updated in 1999.
Sequence of calculation:

1. Definition of the sound power $L_w$ of individual components (motor and gearbox)
2. Calculation of the sum sound power level
3. Calculation of the enveloping surface
4. Definition of sound pressure level on the enveloping surface

We take into consideration the slewing crane described before and calculate, while basing on the standards IEC 60034 and VDI 2159, the sound power levels of the drive units belonging to the two lifting- and closing gears.

The sound power levels, calculated in accordance with the method described, are not far away from the sound power levels measured, while taking into account that the machine house of the slewing crane has a sound insulation factor of approx. 10 dB. The least these values show is a tendency and an order of magnitude. Real values can only be derived from measurements and experiences made with projects realized in the past. It is even possible to forecast the frequencies that will occur, such as the meshing frequencies of the gearboxes and the frequencies of the magnetostrictive motor power resulting from the converter frequencies.

**Spur wheel gearbox**

$$f_2 = z_1 \times n_1 = 21 \times \frac{1480}{60} \text{ [Hz]} = 511.9 \text{ Hz}$$

**Planetary gearbox**

Planetary gearbox with stationary bell-type wheel

$$f_2 = \frac{n_1 \times z_1 \times z_2}{z_1 + z_2} = \frac{1480}{60} \text{ [Hz]} \times \frac{19 \times 80}{19 + 80} = 380 \text{ Hz}$$

The meshing frequencies calculated while taking the number of teeth as basis are clearly verifiable by the structure-borne sound measurements, as well as by the spectra of the airborne sound measurements. So, in the figure 22, there are shown the vibrations taken on the frame to which the drive unit is fixed appertaining to the lifting- and closing gear. In the abscissa there is plotted the frequency, and in the ordinate the time. For every time step the vibration signal, plotted consecutively to the top, has been submitted to the FFT analysis. So, it is formed a space

| Table 11: Slewing crane – Sum sound power of gearbox plus motor |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
|                | No. | Power [kW] | Speed [n[(min) | Motor LWA [dB(A)] | Gearbox LWA [dB(A)] | Sum [dB(A)] | Total [dB(A)] | Measurement [dB(A)] |
| Slewing crane  | 2   | 348        | 1460            | 108             | 112             | 113.5         | 116.5         | 106              |
frequency, time frequency-amplitude landscape. The height of the landscape characterizes the acceleration measured. The blue field represents a view descending vertically towards this landscape. The colour code represented on the left characterizes the corresponding acceleration. In the diagram that can be seen below the abscissa, there is plotted the sequence of frequencies above the frequency. Clearly to see is the maximum at 511Hz. The frequencies that can be seen beside the calculated main frequency are a consequence of the fact that it is a matter of an excited continuum and not of a single degree-of-freedom- system, and that the vibrations get also excited by side effects in other ranges of frequency. It mainly concerns here excitations due to friction, bending vibrations, roll-over frequencies of bearings, etc.

![FFT Analysis Speed influence](image)

Fig. 22: FFT Analysis Speed influence

![FFT Analysis Lifting-Closing Gear 2500Hz](image)

Fig. 23: FFT Analysis Lifting-Closing Gear 2500Hz
A superposition of the airborne and structure-borne sound measurements shows a very good conformity with the maxima position above the frequency.

**Noise reduction measures**

Many noise reduction measures taken on the individual transport equipment are already described before. That is why we deem, at this point, necessary again a systematization of the measures and an explanation of their theoretical background. When planning noise reduction measures there must first be drawn a list from which can be seen all individual noise sources and their sound power levels. All measures to be taken must now start at the loudest source, and dependent on the total sound source levels to be reached, the next loudest sources have to be taken into account. ▶
Sound proofing by insulation

Apart from the possibilities to take directly measures at the source of sound, already described in part before, there is a further proven medium, the sound insulation. Here, the sources of sound, like drive units, get completely covered by means of sound insulation elements. When planning such sound insulations or claddings, care has to be taken that the sound insulation factors given by the manufacturers for the sound insulation elements, or in the sound insulation cladding itself, will not be reached.

The insulation property of a wall with respect to the sound protection is expressed by the so-called sound insulation factor $R$. The sound insulation factor $R$ is the logarithmic ratio that the sound power that impinges on a wall bears to the sound power that passes a wall. The sound insulation factor is dependent on the frequency and the sound wave angle, what cannot directly be seen from the defining equation.

$$R = 10 \cdot \lg \frac{W_i}{W_f}$$

If the sound insulation factor of a sound insulation element is plotted over the frequency, there will be formed the so-called sound insulation curve. It is a function of the rigidity, the resonant frequency, the mass and the coincident frequency. In the sound insulation curve there are three different ranges. Within the range of resonant frequency and coincident frequency, there can be clearly seen invasions of the sound insulation factor. The two ranges are separated from each other by a linear range to which the mass law does apply. The mass law expresses that a doubling of the frequency or a doubling of the basis weight of the wall improves the sound insulation by 6dB. The notation with which we are familiar now enables the mass law to be formulated, as follows:

$$R = 20 \cdot \lg (f \times M^\prime) - 47 dB$$

$$f = \text{Frequenz der eintreffenden Schallwelle [Hz]}$$

$$M^\prime = \text{Masse pro Flächeneinheit} \frac{kg}{m^2}$$

If the incident sound wave shows the same or a similar frequency as the natural frequency of the wall, the wall will be excited to stronger vibrations. In case of the coincidence, the incident sound wave, or the projection of the wave, has the same wave length as the bending wave that is produced in the wall. So, the bending waves in the wall become excited to a higher degree.

If the sound wave strikes a wall below an angle $\delta$, and if the wave length of the incident sound wave $\lambda_0$ is to the bending wave length of the wall $\lambda_B$ as the sine of the incident angle, it will come to coincidence. The wall becomes acoustically transparent within this area. That is the effect called coincidence influx.

$$\sin \delta = \frac{\lambda_0}{\lambda_B}$$

When making use of sound insulation claddings, the area of the resonance influx is dependent on the construction and the area of the coincidence influx on the material.

When planning sound insulation claddings, the thermal dissipation from the housing into the environment, while using sound absorbers, has to be taken into account. Furthermore, there is to be drawn up a thermal balance, considering the environmental and climatic conditions.
• Openings are to be closed or to be equipped with sound absorber, if possible for technical reasons
• Closed rooms are to be equipped with sound absorbers and low-noise fans
• Noise sources and vibrators are to be mounted on flexible supports, or the impedance towards the steel structure is to be increased by large masses
As a rule, large drive units that have a great dead weight on the one hand, and that transmit and absorb high forces on the other, require special constructions. When rating and dimensioning such flexible supports, the small, maximally admissible surface pressure of the elastomers must be considered. If the structural shape does not allow, within the elastomers, a reduction of the transverse stresses, elastomers with fabric inserts will have to be given preference. Pneumatic springs are considered excellent vibration isolators. But they cannot be used in all zones, because of the extensive maintenance work required.

- Vibration-insulated support of the drive units as well as of air-conditioners
- Complete cladding of the machine houses by means of sound insulation cases featuring sound insulation factors that are considerably high. (Here, it is deemed absolutely necessary to point out that the insertion loss factor on a construction composed of sound insulation cases is considerably smaller than that given in the data sheets of the manufacturer for single elements.
- Installation of sound absorbers at the openings required (e.g. for rope passage)
- Installation of low-noise fans
- Low-noise tooth of the gearboxes
- Low speeds of the gearboxes, if possible
- Frequency converters must have high frequency, if possible (lifts)
- Small fall height of material into the bin
- Let always a material buffer in the bin; the bin must never be completely emptied
- Cladding of the bin (dependent on the material to be handled), and provide for a flexible support, if possible
- Dust plants mainly working dry-mechanically are to be avoided, or respective sound insulation measures are to be planned commonly with the supplier.
- Sound insulating cladding of large, sound-radiating surfaces

Fig. 33: Flexible support of air conditioning unit

Fig. 34: Flexible Support Lifting-Closing gear
Some simple rules:

- In the free field, the sound pressure level measured reduces by 3dB with a doubling of the distance from the source. (This way, it is made possible to check whether there is a free field condition).
- A difference in sound power level of 3dB corresponds to a halving or doubling of the sound power.
- If the speed of the gearbox is halved, the sound power level will reduce by approx. 6dB.
- The doubling of the gearbox torque results in an increase of the sound power level by approx. 3dB.

Conclusion

Today, it is enabled plants to be calculated and planned with regard to their sound emission. On account of the complex evolutionary and propagation mechanisms of sound, however, these prognoses are only considered reference values. That is why independent measures on plants already built are absolutely necessary to be capable of understanding acoustic particularities of machines and plants.

The operators must also aware of the fact that the realization of low-noise machines and plants will not be possible cost-neutral.

Industrial scale equipment, spread over a very large area, require a kind of emission deal to be concluded between supplier and client, making it possible to offset loud plant components against quiet ones.

Unfortunately, many aspects, in particular the comparison with different technologies, had to be left aside due to the limitation to fundamental principles. So, a grab-type unloader can either be slewing crane or a portal crane. That has an influence on the kind of noise formation and propagation, and the actions to be taken in the matter of sound protection for both types are different as well, as far as the expenditure on costs and work and their effect is concerned. The table shown below shall help to make this clear.

Seen from a theoretical point of view, the unloading operation could also take place with the aid of continuous ship unloader. Their advantage is the capability of being used for loading operations as well. But at places where this function is not necessary, it would be useful to take the technology of the continuous ship unloaders into consideration.

The transport technology allows a selection from different possibilities, on certain conditions, too. Transports are also possible by means of wheel loaders and trucks. But they would only make sense, if the stockyard topology would be subject to frequent changes. The planner has to take into account not only the dust- and CO2-emissions, but also the energy efficiency.

<table>
<thead>
<tr>
<th>Table 12: Comparison with the sound power of different crane types</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Krupp : Handbuch Lärmgeschützt 1980</strong></td>
</tr>
<tr>
<td><strong>TKF</strong></td>
</tr>
<tr>
<td><strong>Kran1</strong></td>
</tr>
<tr>
<td>Brückenkrane</td>
</tr>
<tr>
<td>16</td>
</tr>
<tr>
<td>Leistung Hubwerk kW</td>
</tr>
<tr>
<td>150</td>
</tr>
<tr>
<td>Leistung Drehwerk/Kraftfahrwerk kW</td>
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<td>2x50</td>
</tr>
<tr>
<td>Leistung Fahrwerk</td>
</tr>
<tr>
<td>6x14,5</td>
</tr>
<tr>
<td>Schalleistungspegel dBA</td>
</tr>
</tbody>
</table>
**Bibliography**

[1] Wirtz, Rainer: Vortrag gehalten auf der Fachtagung Schüttgutfördertechnik 2010 in München


[6] DIN 45630 Grundlagen der Schallmessung; Physikalische und subjektive Größen von Schall

[7] DIN 45635 Schallmessung an Maschinen

[8] DIN 45641 Mittelung von Schallquellen

[9] DIN EN ISO 4871 Acoustics; Noise labelling of machinery and equipment

[10] DIN 45661 Schwingungsmeßeinrichtungen - Begriffe


[12] IEC 60034 Drehende elektrische Maschinen


[17] VDI 3749 Emissionskennwerte technischer Schallquellen


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**Symbol | Unit | Designation**

| A | [m²] | Area |
| c | [m/s] | Sound velocity = Speed of sound |
| \(c_{luft}\) | [m/s] | Sound velocity of air = 344 |
| \(\delta\) | | Angle |
| E | [N/m²] | Young's modulus |
| E' | [N/m²] | Modulus of resilience |
| f | [Hz] | Frequency |
| \(f_c\) | [Hz] | Coincidence frequency |
| \(f_r\) | [Hz] | Resonant frequency |
| \(f_m\) | [Hz] | Masking frequency |
| G | [N/m²] | Shear modulus |
| I | [Wm²] | Sound intensity |
| \(i\) | | Lower index Sum |
| K | Adiabat exponent |
| \(K_0\) | Adiabat exponent of air = 1,4 |
| K | [N/m⁴] = [kg/ms²] | Bulk modulus |
| L | [m] | Length |
| LAeq | dB(A) | Energy-equivalent sound level |
| \(L_{eq}\) | dB | Sound level (arbitrary) |
| \(L_{a; eq}\) | dB | Averaging level |
| \(L_{a, dB}\) | dB | Sound pressure level |
| \(L_{a, dB}^{(A)}\) | dB | A-weighted sound pressure level |
| \(L_{a, dB}^{(A)}\) | dB | Sound source level |
| \(L_{a, dB}^{(A)}\) | dB | Enveloping surface size |
| \(L_{a, dB}^{(A)}\) | dB | Sound power level |
| \(L_{a, dB}^{(A)}\) | dB | A-weighted sound power level |
| \(L_{a, dB}^{(A)}\) | dB/m | Specific sound power level |
| \(\lambda\) | | Wavelength / Sound wave |
| \(\lambda_b\) | | Bending wave length Wiel |
| M' | [Kg/m³] | Specific mass |
| \(\mu\) | | Poisson's ratio |
| \(n\) | [1/min] | Speed |
| \(n\) | | Upper index Sum |
| \(\bar{n}\) | | Normal vector |
| P | Pa = [1N/m²] | Sound pressure |
| \(P_{a, 0}\) | Pa | Reference sound pressure = 0,00002 |
| \(P_{a, max}\) | Pa | Maximum sound pressure |
| \(P_{eff}\) | Pa | Effective value / Sound pressure |
| \(P_k\) | [W] | Power |
| \(P_{w, 0}\) | W | Sound power |
| \(P_{w, 0}\) | W | Reference sound power = 10-12 |
| \(P_{w, 0}\) | dB | Sound insulation factor |
| \(R\) | [J/kgK] | Gas constant |
| \(R_{v}\) | [J/kgK] | Gas constant of air = 287 |
| \(R_s\) | | Sound intensity |
| r | [m] | Radius |
| \(S_{ref}\) | [m²] | Reference surface = 1 |
| S | [m²] | Surface |
| \(\Sigma\) | | Total |
| T | [s] | Period |
| \(T_{K}\) | | Temperature |
| \(v\) | [m/s] | Sound velocity |
| \(v\) | [m/s] | Speed |
| V | [m³] | Volume |
| \(\rho\) | [kg/m³] | Density |
| \(\rho_{luft}\) | [kg/m³] | Atmospheric density = 1,2 |
| \(\rho x\) | [kg/m²] | Characteristic acoustic impedance |
| \(\pi\) | | Cosecant factor |
| \(W_s\) | [W] | Sound power striking a wall |
| \(W_w\) | [W] | Sound power passing a wall |
| \(x\) | | Free variable |
| \(y\) | | Free variable |
| z | | Number of teeth |
| \(\nu\) | | Effective value |
| \(\rightarrow\) | | Vector |
| 1 Watt = 1/2π-f[Hertz]² | 1 Pa = 1 N/m² = 1 kg/s² |
| 1 bar = 100.000 Pa |
Extensive measures are put in place to protect the drilling team and mine infrastructure from sudden blowouts of gas and fluid during exploration drilling work. The basic technique is to install a standpipe of at least 5 m in length, which forms the connection between the strata and the safety fitting, i.e. the blowout preventer. The safety system comprises the safety valve, the tee connection, the ram reventer and the sealing device. The annular preventer is not part of the safety system.

These various elements perform the following functions: the safety valve is used to seal the hole in order to prevent the ejection of fluids and/or gases, this first requiring the drillrod to be withdrawn from the hole. The downstream tee connection operates in conjunction with the safety valve to feed the required amount of drill mud into the annulus, while in an emergency it is used to add a suitable densifier, monitor the pressure level and allow fluids to be drained off in controlled doses. In the event of an emergency arising the ram reventer is able to close off the annulus with the drillstring still in the hole. If the drillstring is outside the preventer the open hole can be closed over by means of the sealing device.

The annular preventer seals the annulus between the drillstring and the open sealing device while the drilling system is in operation. After the installation of the standpipe and the fitting of the safety devices the system...
is to all intents and purposes sealed by the injection of
the drill mud, whether the drillstring is in place or not. To
this effect it is necessary to apply 1.5 times the calculated
hydrostatic pressure as a test pressure, as governed by
the depth reached at the drilling site.

The relevant personnel are required to attend special
training sessions (courses include ‘Principles of well
control’) at the Celle Drilling School in order that the
installed safety equipment can be deployed properly and
rapidly should an emergency arise.

Exploration drilling programme at K+S
KALI’s Zielitz potash mine

The Zielitz potash mine is one of six sites in Germany
where K+S KALI GmbH extracts potassium and
magnesium salts. These are used as feedstock for a
large range of potash, magnesium and sulphur fertilisers
and are also processed into products for technical,
commercial and pharmaceutical applications.

Zielitz started production in 1973 as the most recent
addition to the K+S KALI group. The mine employs a
workforce of some 1,700, making it one of the largest
employers in Saxony-Anhalt.

For 25 years potash mining at this site has focused
exclusively on the Zielitz 1 deposits. A roadway system
is underway getting established since 1998 to get access
to the mining concession Zielitz 2.

Military activities on the Colbitz-Letzlinger heath
have prevented this area of about 36 km² from being
surveyed by surface exploration drilling and geophysical
measurements. All tunnel developments completed to
date have been undertaken on the basis of and under
the cover of underground exploration work.

In order to fill this gap in the exploration map and
provide back-up for its own survey activities K+S KALI
GmbH commissioned Thyssen Schachtbau GmbH in
early 2007 to carry out horizontal exploratory drillings
in the Zielitz 2 area of the mining concession. Starting
out from a number of drilling chambers the team drilled
a series of horizontal holes in two to four directions and
with a maximum length of 2,500 m.

The aim was to identify the location of the Ronnenberg
potash seam (K3RO) at predetermined intervals by using
a drilling programme comprising undulating holes and
deviated holes.

As the survey zone is located in an area of deposits
that is prone to salt migration it was also necessary to
explore the adjacent salt horizons in the roof and floor
(barrier layer identification). The interim results from
some 17,200 m of drilling were collated in October 2008
and yielded 28 seam exposures and 26 barrier layer
verifications.

The exploration programme is being carried out using
a universal drilling machine with an electro-hydraulic
drive (type HBR 201, supplied by Hütte) and an electrically
powered Triplex mud pump. The company has invested
heavily in this new drilling system with its various
attachments in order to ensure that the requirements
profile is being met to the full.

The drillers use the counterflush coring method with
saturated salt flushing. This highly effective and cost
efficient core drilling technique has already proved
successful in horizontal exploration work where special
performance requirements are involved. This system
differs from the wireline coring method in that reverse
mud flush circulation is used to facilitate uninterrupted
Schematic diagram of
borehole curvature

- Schematic diagram of borehole curvature
core recovery. The annulus between the drillstring and the sides of the hole is sealed by a preventer system that allows reverse flushing (counter-flushing) via the annulus. The preventer closing device also acts as a safety system to prevent the ingress of gas and brine. Thyssen Schachtbau GmbH has been carrying out a wide range of drilling projects for the salt mining industry for more than twenty years and the company therefore possesses the know-how needed for special drilling operations of this kind.

The excellent working relationship between client and contractor and the degree of satisfaction recorded by K+S KALI with the quality of the work led to a second drilling project being started at Zielitz in November 2008. In order to obtain more information on an additional potash seam vertical holes of 100 m average length are being drilled from existing workings at the level of the present working horizon. The aim of this operation is to
obtain extensive data on the extent, formation, thickness and potash content of the Stassfurt seam (K2).

In order to undertake this exploration programme Thyssen Schachtbau GmbH opted for an Atlas Copco all-hydraulic Diamec 262 drilling machine, which is being employed in conjunction with a special wireline coring system using the dry-drilling technique. The flushing medium, in this case air, is cleaned by being passed through a dust filter unit after exiting from the annulus. The drill rig and its various fittings are mounted on a specially built transport pallet.

With the wireline coring process the core bit is driven by a rotating outer core barrel, while an inner core tube, which is not part of the rotary movement, is located within the outer barrel casing. This arrangement allows the drill core to be pushed up undamaged into the inner core tube, where a corecatcher installed in the inner core tube detaches it from the rock at the end of the drill run.

In order to recover the drill core the inner core tube is released from the outer barrel by means of an overshot tool and is then withdrawn from the hole using a wireline winch. The outer core barrel and drillstring remain in the hole and the complete outer barrel assembly (rotating drillstring) is only withdrawn if and when the drill bit has to be changed over.

**Exploration drilling programs at K+S KALI’s Sigmundshall potash mine**

Sigmundshall mine, which is located to the north-west of Hanover near the town of Wunstorf, began operating in 1896 as the ‘Wunstorf Potash Drilling Company’ and was connected to the Steinhuder Meer railway in 1906. The three active shafts, namely Sigmundshall, Kohlenfeld and Weser, are all sited to the south-west of the zone.

Thyssen Schachtbau GmbH has been engaged in exploration drilling work at this site since March 2007. This involves both horizontal and vertical drilling with hole deviation using counterflush and wireline coring methods.

The exploration work carried out at the Weser shaft placed particularly high demands on the operating crew and technical equipment. As at Zielitz this operation used...
a Hütte type HBR 201 universal drilling machine with electro-hydraulic drive and an electrically powered Triplex mud pump.

**Project description**

A vertical NQ borehole 700 m in depth was drilled from the starting point, which was the former mine fan workshop at the 440 m below sea level (b.s.l.). After the hole had been surveyed the diameter was taken out to 96 mm. The borehole was then surveyed with a georadar probe (EMR). After the results had been processed the four deviation points were determined according to the geological requirements and technical possibilities. From this vertical drilling deviated holes – each with a down-the-hole motor and a deviation of about 2° over 10 m – were drilled in the predetermined direction at four different levels, namely at 239 m, 117 m, 72 m and 69 m. A 500 m b.s.l. cored section was then drilled from a start channel using the wireline drilling technique.

After encountering some initial problems in the vertical section all four deviated holes were completed to the full satisfaction of the client.

Thyssen Schachtbau GmbH is looking forward to further successful collaboration with K+S KALI GmbH on future projects.

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Vertimills® are globally recognized as energy efficient grinding machines, but reduced media consumption, lower installation cost, minimal maintenance, and minimal liner wear make the Metso Vertimill® solution the lowest total cost of ownership in many applications, substantially improving the profitability of copper concentrators. In the past twenty years more than 80 Vertimills® have been sold for copper concentrators, with 24 of those in the last two years alone. The Metso Vertimill® has become the standard in regrind applications, but they have been slow to be adopted in coarser applications. The mill has been proven to grind more efficiently than ball mills even with feeds as coarse as 6 mm. Much of the hesitation to advance Vertimills in primary and secondary grinding is the requirement for large quantities of Vertimills® to perform the same task as a single ball. While there are still cost advantages with multiple Vertimills compared to a single ball mill, the newly developed 3000 HP (2240 kW) Vertimill® lowers the total cost of ownership even further. By replacing ball mills in power intensive grinding applications such as grinding SAG mill and HPGR products, the savings that have been experienced in regrind applications can be multiplied further. Typically, the total cost of ownership of the Vertimill® compared with traditional ball mills is 35% less. Potentially every MW of ball mill power saved in a primary or secondary application means a NPV cost savings of US$ 10 million and 80,000 tonnes of carbon saved over a ten year mine life. With increasing energy costs and environmental consciousness, it is an economic inevitability that Vertimills® will become the standard in secondary grinding, further lowering the processing costs of copper concentrators.
Introduction

The Vertimill® is a unique product offered exclusively by Metso that has a long history in the metallic mining industry. The technology was originally developed in the 1950’s in Japan. In 1979, Metso Grinding division (then Koppers) acquired the license for the technology. During that time, Metso was successful at operating the mills in their first large scale metallic operations, but we found the unit had many mechanical short comings with its original design. It was originally intended for industrial mineral applications and was not robust enough to meet the demands of the metallic mining industry. The machine was redesigned to improve grinding efficiency, minimize maintenance and down time, and maximize wear life - the Vertimill® was born. In the twenty years since the Vertimill®’s development, it has built the largest installed base of any stirred milling technology.

The Vertimill®, available in standard sizes from 20 – 3000 HP (15 – 2240 kW), has a relatively large practical operating range, handling feed sizes from 6 mm and grinding to sub 20 microns products. The capacity of the machine is relative to the required power input for the intended grind, but mills have been operated with throughputs exceeding 500 mtph.

Vertimills® are primarily selected because of the operational cost savings they have over other grinding mills. The total cost of ownership for a Vertimill® is almost always significantly less than a traditional horizontal ball mill solution. The Vertimills® advantages include:

- Reduced energy consumption
- Reduced media consumption
- Reduced Maintenance due to machine simplicity
- Lower Installation Cost
- Less floor space
- High Availability
- Long Wear Life
- Quiet operation (less than 85 db possible)
- Greater operational safety

The most significant of these advantages in terms of total cost of ownership are energy consumption and grinding media consumption (which is directly related to energy consumption).

Mechanically, the Vertimill® is a very simple machine with an agitating screw suspended into the grinding chamber, supported by spherical roller bearings, and driven by a fixed speed motor through a planetary gearbox. The Figure 1 shows the Vertimill in its standard arrangement with all of its major components.

Operating conditions of the Vertimill

The majority of Vertimill® copper grinding installations are in Chile and most are in concentrate regrind applications. Of the entire Vertimill® population worldwide, 85% by power are in regrind applications. Historically, copper regrind applications require products of approximately 35 microns. For products finer than this, fluidized stirred mills would be another option, but many operations don’t yet grind that fine with copper concentrate.
**Energy Considerations**

The Vertimill® has been proven to provide energy savings ranging from 30% to greater than 50% compared with traditional ball mills in copper applications. The finer the product, the more efficient a Vertimill® would be than a ball mill.

The improved grinding energy efficiency of the Vertimill® is due largely to the effect of the vertical arrangement. A horizontal Ball mill relies on the tumbling action of the slurry and media for both impact breakage and attrition grinding. However, impact energy is generally not as efficient as attrition grinding since much of the impact energy is wasted if the grinding balls impact the liners or other steel balls. The most efficient grinding zone inside of a ball mill is known as the “kidney” because of its shape and it is efficient because the grinding media and particles are constantly in contact with one another and grind by attrition. Figure 2 shows the flow of the grinding media inside of a Vertimill®. The screw rotates slowly enough that media is not fluidized but settles by gravity. The screw pulls media up the center of the mill, which eventually cascades over the edge of the screw creating a general downward flow at the mill perimeter. As you can see in the figure, the velocities of the particles are quite low because the media stay in contact with one another, while in a ball mill media can be in free fall through open space. The entire grinding action inside of the Vertimill® closely mimics the attrition grinding in the “kidney” of a ball mill.

The vertical arrangement, also, contributes to minor internal classification of particles, reducing over grinding, thus, increasing efficiency. As the feed material enters the top of the grinding chamber, the downward travel of the material into the grinding media is influenced by the uprising velocity created by the recycle flow. This uprising velocity removes or “washes” out fine product size material before entering the grinding media and exits the mill to the external classification step where it is removed from the system with very little energy applied.

The second reason for the improved grinding efficiency is that the Vertimill® effectively uses finer media. Since a ball mill relies partially on impact breakage, a certain size grinding ball is required generate enough kinetic energy...
while tumbling. In a Vertimill® the larger ball sizes isn’t required because impact isn’t the grinding mechanism. Therefore, the mill can be charged with a smaller media top size creating an overall smaller size distribution. Table 1 shows how a small change in media size can have a big impact on the total grinding surface area. In general, a Vertimill® size distribution has greater than three times the surface areas of an equivalent ball mill grinding charge.

<table>
<thead>
<tr>
<th>Ball Size [mm]</th>
<th>Surface Area [m²/mton]</th>
<th>Number of Balls/mton</th>
<th>Number of Balls normalized</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>33,3</td>
<td>4244</td>
<td>1</td>
</tr>
<tr>
<td>40</td>
<td>41,7</td>
<td>8289</td>
<td>2</td>
</tr>
<tr>
<td>30</td>
<td>55,6</td>
<td>19649</td>
<td>5</td>
</tr>
<tr>
<td>20</td>
<td>83,3</td>
<td>66315</td>
<td>16</td>
</tr>
<tr>
<td>15</td>
<td>111,1</td>
<td>157190</td>
<td>37</td>
</tr>
<tr>
<td>10</td>
<td>166,7</td>
<td>530516</td>
<td>125</td>
</tr>
<tr>
<td>5</td>
<td>333,3</td>
<td>4144132</td>
<td>1000</td>
</tr>
<tr>
<td>3</td>
<td>555,6</td>
<td>19648758</td>
<td>4630</td>
</tr>
</tbody>
</table>

For example, when the Vertimill® was first tested in hard rock applications, most of those were secondary grinding roles. A Vertimill® was operated in place of a ball mill in a secondary application grinding the product from a 12’ diameter SAG mill. The energy savings for the coarser secondary grind compared with the ball mill average 34.2% (Pena et al, 1985).

### Media Considerations

Media consumption is directly related with energy efficiency. At a concentrator in Mexico, Vertimills were put in place of existing ball mills. In addition to the expected 35% decrease in grinding energy, they experienced reduced media consumption from a previous average of 821 g/t to 429 g/t, or a 48% reduction. The savings in media consumption is for two reasons. First, less energy is being consumed with grinding, so it follows that less grinding media will be consumed. Second, since the wasteful impact breakage of ball-to-ball or ball-to-liner is eliminated, there are fewer ball fractures and the media inside the Vertimill can maintain its shape and usefulness. If the consumptions above are normalized into kg/kWh, they become .065 kg/kWh for the ball mill and .05 kg/kWh for the Vertimill®. The difference in these two figures is due to the reduction of impact energy and ball fracture, and when actual consumption per ton is calculated (media consumption * specific grinding energy), the 35% savings in energy is realize.

Energy efficiency and environmental consciousness is very important today. Many companies are under pressure by the public and the government to become more environmentally friendly or “green.” A savings in energy usage not only means big savings in operational cost, but also a reduction in carbon emissions. Energy is also used to create grinding media, so a reduction in media consumption is also a reduction in net carbon emissions. Most of the focus in the inductry has been on a smaller media top size creating an overall smaller size distribution.
direct energy usages, but indirect energy usage must also be considered. In direct energy would be the energy cost associated with grinding media. Many countries have already instituted cap and trade systems and carbon taxes with more to come. As political pressure increases to control carbon emissions, the cost of energy will continue to outpace inflation. Also, mining practices are generally viewed by the public as a hazard to the environment. Using energy efficient technology will not only decrease operating costs, but could also generate a more positive public opinion since the most energy efficient technology is being used. In August of 2009, the Mining Journal reported that the Australian government responded to the EIA (environmental impact assessment) with concerns over the potential green house gas emissions. Using Vertimill® technology may help project get the require environmental permits as people are more concerned about carbon emissions.

Economics of Secondary Grinding with Vertimills®

If the entire grinding energy of a concentrator is considered, there is significantly more energy in grinding the whole stream than concentrate, so it would follow that there should be more Vertimills® in secondary than in regrind applications. But, as previously stated, the majority of Vertimills® are in regrinding applications. One of the reasons for this is that Vertimills® are most efficient in finer grinds, so naturally they will be applied first where they can achieve the greatest savings. Vertimills® are still a new concept to many operators that are used to ball mills and there remains resistance by some to adopt the new technology to Secondary applications. In the past, for many operations, power and media costs were relatively low but since they have increased, and are predicted to increase, faster than inflation, now is the time that Vertimills® will move into the larger grinding roles.

Another reason for slow acceptance in whole stream grinding may have been the previous limitation in Vertimill® sizes. As the Vertimill® has developed, larger and larger sizes have been created. The first Vertimills® were installed in the mining industry, were only 450 HP (335 kW) and it took many years to increase the size up to 3000 HP (2240 kW), not because of mechanical limitations, but the quest for the site which would try the first to install the new size. However, for a large concentrator, multiple Vertimills would still be required. The Vertimill® has many other advantages beyond energy and media. It is a vastly simpler machine compared with a large ball mill which means that multiple Vertimills® are still less maintenance than a single ball mill - also the Vertimill® has superior wear characteristics and a greater operational safety. Many times, a multiple mill arrangement offers superior circuit operability and flexibility.

Table 2 shows the assumptions for a sample calculation to determine the energy, media, and carbon savings of using Vertimills® in place of ball mills.

### Table 2: Assumptions

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Required Ball Mill Power</td>
<td>3333 kW</td>
</tr>
<tr>
<td>VTM Efficiency</td>
<td>70 %</td>
</tr>
<tr>
<td>Required Vertimill® Power</td>
<td>2333 kW</td>
</tr>
<tr>
<td>Power Cost</td>
<td>0,5 /kWh</td>
</tr>
<tr>
<td>Circuit Availability</td>
<td>93 %</td>
</tr>
<tr>
<td>Ball Mill Media Consumption</td>
<td>0,065 kg/kWh</td>
</tr>
<tr>
<td>Vertimill® Media Consumption</td>
<td>0,05 kg/kWh</td>
</tr>
<tr>
<td>Delivered Media Cost</td>
<td>1150 $/mt</td>
</tr>
<tr>
<td>Annual Power Cost Increase</td>
<td>4 %</td>
</tr>
<tr>
<td>Annual Media Cost Increase</td>
<td>4 %</td>
</tr>
<tr>
<td>Carbon Dioxide Emissions</td>
<td>0,609 kg/kWh</td>
</tr>
<tr>
<td>Energy in Media</td>
<td>6 kWh/kg</td>
</tr>
<tr>
<td>Internal Rate of Return</td>
<td>8 %</td>
</tr>
</tbody>
</table>

### Table 3: Vertimill® savings

<table>
<thead>
<tr>
<th>Year</th>
<th>Energy Savings</th>
<th>Media Savings</th>
<th>Carbon Savings (mt of CO2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$ 407,340</td>
<td>$ 936,882</td>
<td>7,938</td>
</tr>
<tr>
<td>2</td>
<td>$ 423,634</td>
<td>$ 974,357</td>
<td>7,938</td>
</tr>
<tr>
<td>3</td>
<td>$ 440,579</td>
<td>$ 1,013,332</td>
<td>7,938</td>
</tr>
<tr>
<td>4</td>
<td>$ 458,202</td>
<td>$ 1,053,865</td>
<td>7,938</td>
</tr>
<tr>
<td>5</td>
<td>$ 476,530</td>
<td>$ 1,096,019</td>
<td>7,938</td>
</tr>
<tr>
<td>6</td>
<td>$ 495,591</td>
<td>$ 1,139,860</td>
<td>7,938</td>
</tr>
<tr>
<td>7</td>
<td>$ 515,415</td>
<td>$ 1,185,455</td>
<td>7,938</td>
</tr>
<tr>
<td>8</td>
<td>$ 536,032</td>
<td>$ 1,232,873</td>
<td>7,938</td>
</tr>
<tr>
<td>9</td>
<td>$ 557,473</td>
<td>$ 1,282,188</td>
<td>7,938</td>
</tr>
<tr>
<td>10</td>
<td>$ 579,772</td>
<td>$ 1,333,475</td>
<td>7,938</td>
</tr>
<tr>
<td>NPV</td>
<td>$ 3,201,290</td>
<td>$ 7,362,967</td>
<td>79,382</td>
</tr>
</tbody>
</table>
The Development of Vertimill

US$0.05/kWh is a typical number for a conveniently located concentrator. There are many more remote locations some with energy costs as high as US$0.20/kWh which would make the selection of Vertimills even more favorable. The cost of the media is not simply the cost of the steel balls, but the delivered cost. Therefore, more remote locations will have much higher media cost, some as high as US$2000/mt; so US$1150/mt is again a conservative figure. It is estimated that each kg of steel requires an average 6 kWh of energy (Pokrajic and Morrison, 2008). The United States Department of Energy determined that for every kWh of power generated in the US, the average Carbon Dioxide emission is 1.341 lbs or .609 kg (DOE, 2002).

Table 3 shows the savings in energy and media cost, and carbon dioxide emissions for 1MW of power.

The total NPV savings of energy and media over a ten year mine life of 1 MW of grinding energy by using Vertimills® instead of ball mills is approximately US$10 million. The carbon savings are approximately 80,000 tonnes. These figures are scaleable, and can be used for a quick calculation of potential operational savings in a large concentrator.

Consider a 100,000 mtpd copper concentrator that would have approximately 40 MW of ball mill power. Vertimills® could make the same grind at 30% less energy or 28 MW. 12 MW of energy would be saved, and using the figures calculated above, that would equate to US$120 million savings in energy and media costs and 960,000 tonnes of carbon.

The Vertimill® is a proven technology that offers considerable savings in media and energy operating costs that will lower the cost of producing copper significantly. Also, the environmental impact of a copper concentrator is significantly decreased. In the future, it is extremely likely that more sites will adopt this technology for more of their grinding needs to improve their profitability.

Bibliography


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It is precisely in this period, when the construction market is still shaky and uncertain, that is clear how MB’s crusher buckets offer the best solution ever for those who use them: a solution that offers many advantages and allows companies to cut costs and, in the meantime, to save time and money.

Firstly, MB’s crusher buckets guarantee practical use and reduced costs for material disposal, transport and supply and secondly, this product represents the typical investment aimed to boost the micro/macro economic cycle, now and in the future.

For this reason, whoever chooses MB’s crusher buckets does it not only for work requirements but also because they are looking to upgrade their equipment fleet and achieve higher work quality, in full respect for the environment.

We also should not underestimate the fact that the operating process of a crusher bucket is extremely simple. First of all, the material can be taken directly to a yard or to any other location. This is followed by a phase in which the material is prepared for the work cycle by means of grabs and jackhammers. This is how the loose material crushing process begins, the material having been previously picked up, hoisted, carried and unloaded by the same bucket, and lastly grounded at the desired thickness. The resulting material can be reused for other jobs at the same worksite or be taken to other worksites and used to build yards, road embankments, drainage systems and for filling in various excavations.
In general, for anyone operating in the earth moving sector, the MB crusher bucket necessarily becomes a complementary piece of equipment. And the reasons, in addition to the ones already given, are simple: MB’s crusher bucket saves time, energy, resources and man/hours; it also leads to a significant reduction in costs relating to the entire disposal and procurement activity, precisely due to how easily the crusher bucket can be moved and its on-site use.

On top of the ever-important advantage is the reduction of environmental pollution, a fight that MB has been staunchly supporting, side by side with all its customers (the company is currently being certified ISO 14001). Indeed, the reused materials generated by excavations or demolitions means that the site will still be formed by the same materials as before the jobs were carried out. Not to mention the pollution generated by trips to the dump to dispose of the material and trips to procure it, as well as costs resulting from road wear caused by the trucks travelling back and forth.

All this has an even greater value if we consider that many townships have enacted more stringent laws on trucks passing through their territory; in some cases, the law prevents trucks to make more than two trips per day.

Special attention should also be paid to the crusher bucket being employed to crush inert materials to be subsequently used to form the stabilized pavement for road foundations. In fact, many companies have chosen the MB crusher bucket as a must-have tool for their daily operations: the demolition and roadwork sector requires the recycling and production of materials to be reused, also offering the significant opportunity to sell directly the rubble and gravel.

There are many accounts by entrepreneurs who have realized that the profitability of the crusher bucket is comparable to, if not higher than, a regular movable crusher. With the added advantages of easy installation and unbeatable use.
Moreover, the impact of the crusher bucket is quite different from that of a fixed or movable crusher, especially when used in city centres: the use of a traditional crusher is often hindered by its size, which limits its use in many urban areas. The crusher bucket, on the other hand, used in conjunction with the excavator, can be employed at all urban worksites, including those located in tight spaces as well as in mountainous or hilly areas, where the use of a traditional crusher would not be feasible if only for the difficulty in transporting it to the site.

In any event, it should be taken into account that traditional installations always require an excavator for loading the crusher and another piece of equipment to clean the machine, without counting the preliminary operations of logistically setting up the material to be crushed.

Therefore, choosing a crusher bucket turns out to be a consistent choice for cost savings as well as for more “environmentally-friendly” operations: crusher buckets are easy to transport and inexpensive in terms of maintenance, they do not require their own operator in addition to the one assigned to the excavator, and they save the fuel required by a movable crusher, which would be nevertheless supplied by an excavator. Not to mention the eco-friendly “cleanliness” of the jobs, carried out with the minimum amount of dust being raised and noise levels with low environmental impact.

MB S.p.A.

founded in Breganze in 2001, today exports in over 100 countries and is highly appreciated for its innovative and technological products and for the quality of its service. The ability to react to the market and the technical service provided to a large number of customers has contributed to making the MB brand famous throughout the world.

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Internet: www.mbcrusher.com
NEW BOOMER T1 D: MEETS CHALLENGES IN NARROW-VEIN MINING!

A new face drilling rig for narrow tunnels and mines has been introduced by Atlas Copco. Based on its well-proven predecessor, the Boomer 104, the new Boomer T1 D offers an impressive array of technical and environmental improvements.

In the world of underground mining where narrow tunnels and drifts have limited space, a small and flexible face drilling rig is worth its weight in gold. Since the 90’s, this role has been filled by Atlas Copco’s Boomer 104. Now Atlas Copco has launched its successor – the Boomer T1 D.

The new machine retains the features and capabilities of the well-liked Boomer 104, but now introduces an extensive range of improvements and upgrades, all aimed at improving productivity, safety and operator comfort.

The range of new improvements and options include a more powerful and cleaner Tier 3 engine for higher tramming speed and environmental benefits. The boom suspension system reduces stress on the machine, thereby increasing service life and improving operator comfort when driving. A more ergonomic and comfortable cabin with better visibility is part of the optional extras, and the serviceability has been improved with more accessible service points.

An important improvement was made on the carrier frame. The new frame is stronger, has a lower centre of gravity and has an oversized articulation to cope with demanding operating conditions.

The first Boomer T1 D was tested at the Lovisa lead/zinc mine in Sweden where it achieved top results compared to the mine’s previous Boomer 104. Operators of the machine praised the improved ergonomics and drilling performance during the trial.

– We know our customers liked the Boomer 104 for its flexibility and small size, but we think people will fall in love when they see the Boomer T1 D, says Peter Bray, Product Manager Face Drilling Equipment Atlas Copco.

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Internet: www.atlascopco.com

Atlas Copco Underground Rock Excavation is a division within Atlas Copco’s Construction and Mining Technique business area. It develops, manufactures, and markets a wide range of tunneling and mining equipment for various underground applications worldwide. The division focuses strongly on innovative product design and aftermarket support systems, which give added customer value. The divisional headquarters and main production center is in Örebro, Sweden.
Safety, ergonomics and high productivity have been in focus when designing the Boomer XL3 D for users who prefer a traditional direct control system. The Boomer XL3 D has a modern, attractive design, and it also offers several innovations. The new rig will be on display at Bauma China at the end of November.

Great emphasis has been placed on the interaction between operator and machine. The work space is now less noisy thanks to the improved control system that has a reduced amount of high pressure hoses near the operator.

The control system’s hydraulics also provides improved precision and simplicity and together with the new ergonomic control panels this is advantageous for both safety and productivity. The easily accessed service points are also an important aspect of the ergonomic design.

The rig has a FOPS-approved canopy, which can also be fitted with a vertical lift of 1 100 mm, to ensure excellent visibility over the working area. The optional cabin offers a high degree of operator comfort with a noise level inside
the cabin below 80 dB(A). In addition, the air-conditioning unit ensures a comfortable temperature level.

To reduce particle and nitrogen oxide emissions, Boomer XL3 D is equipped with an efficient Tier III engine.

—For increased productivity and precision, the rig is also prepared for the optional Feed Angle Measurement (FAM) 3. The system helps the operator to drill precisely according to plan, resulting in considerably less over- and underbreak and gives longer rounds, says Mathias Edhammer, Product Manager Face Drilling Rigs, Atlas Copco.

The Boomer XL3 D can be fitted with a wide range of powerful, reliable rock drills for different rock conditions, including the well-proven COP 1638, COP 1838 and the powerful COP 2238.

More information, technical specification and movie is available in the Atlas Copco product catalogue: Boomer XL3 D
New bucket and ground engaging tools produce major improvements in tests. Mining and tunneling companies using Atlas Copco Scooptram loaders can now raise their productivity and lower fuel consumption thanks to two new design improvements.

A new generation bucket that is lighter, shorter and faster combined with new ground engaging tools has been launched by Atlas Copco for its Scooptram loaders, leading to higher productivity and lower fuel costs. — Lower total cost per ton of ore!

According to Peter Trimmel, Product Manager at Atlas Copco, tests of the new third generation bucket (GIII) and Atlas Copco’s Ground Engaging Tools (GET), have produced excellent results. Operating time in the test muck pile was cut by seven percent while fuel consumption was reduced by eight percent. An added benefit is that the bucket is more robust than previously and is designed to withstand extreme wear.

Throughout the test period, the same loader and driver were used. Driver Totte Nilsson, who has been driving different types of loaders in different mines and countries for 20 years, says:

- I think this new GIII bucket is remarkable. Just upgrading your Scooptram ST1020 or ST1030 with the new GIII bucket will be a great improvement. And if you equip the GIII bucket with GET you gain even more.
GET ground engaging tools are additional components that are bolted onto the front edge of the bucket, and sometimes also on the sides, in order to increase the bucket’s ability to attack and penetrate different muck pile formations.

- It cuts like a knife through butter. The job gets done much easier with the new GIII bucket.

- Our team has put a lot of effort into testing and choosing the best steel available for the new GIII bucket, says Anders Persson, Manager of the Atlas Copco Materials & Rock Drill Laboratory.

- The GIII bucket is now made of very wear resistant steel which will reduce maintenance costs.

When the GIII bucket is equipped with the ground engaging tool GET it is said to cut through a muck pile “like a knife”. GET’s designer Kjell Karlsson says:

- We have made the Atlas Copco GET very sharp and aggressive, and because of this it will stay sharp all the time until it is time to change the parts. We believe the user can wear off almost fifty percent of the material on each shroud until it is time to change the parts.

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Atlas Copco Underground Rock Excavation is a division within Atlas Copco’s Construction and Mining Technique business area. It develops, manufactures, and markets a wide range of tunneling and mining equipment for various underground applications worldwide. The division focuses strongly on innovative product design and aftermarket support systems, which give added customer value. The divisional headquarters and main production center is in Örebro, Sweden.
Star screens can be compared to tires. There are tires for cars, trucks, wheel loaders, etc., with different attachments, either with or without spikes. This is more or less the same with star screens.

Even higher screening performance, even more difficult screen inserts, even finer screening, even longer operating lives…..and even better prices.

Since 1989, the star screening technique has constantly been advanced at the Backer company, as research and development are seen as investments into the future. This is of advantage for the client, for the Backers company, as well as for the environment. It enables more rational operating procedures with higher throughput, minimization of wear and consequent savings of resources, as well as offering the possibility to process material with poor flow properties.

In 2010 the centerpiece of the star screen technique – “the star screen shafts and the screen deck” were completely overhauled. From 2011 onwards, the Backers company will offer the “Backer premium star sieve”, in addition to the classic star screen.

In the classic version, star screens with a cast-on hub are inserted. In this system the stars are mostly put on from one side. A fine distribution with small stars is particularly difficult.

In the “Backers premium star screen” star discs made from elastic material, as well as hard distance parts with long operating life and low adhesion are used.

The stars and the massive outer discs are fixed very accurately from the sides, which result in a very accurate distribution. A fine sieving of up to 5 (4) mm cross cut is possible. Furthermore the sieve deck and
the sieve frame has been optimized. The “Backers Premium Star Screen” system works on the basis of classical square shafts, but also with a new drive and a change system.

In addition the Backers company offers the new Premium Star Screen also as “High-Performance Screen”. In this case spring steel inlets are vulcanized in the star spikes. The spaces between the star discs are cleaned even better, they are continuously cleaned by a scraper. The spring steel scrapers are inserted into the elastic spikes and cannot be deformed or broken. These stars also convince during screening of material which is difficult to screen.

These stars also have a long operating life when screening earth with stones. Now a smaller sieve cut is possible while screening cohesive soil, sludge, etc. Through the scrapers the screening waves run easier, which reduces the driving force. This results in higher screening performance, longer operating life, lower fuel consumption.

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Europe’s largest stainless steel plant in Tornio, Finland – producing 1.7 million tons a year – recently opened a new slag processing plant in September 2010. The main components of this new plant are two powerful alljig®-jigging machines, ordered by TAPOJÄRVI, which runs the plant on behalf of OUTOKUMPU. The slag, a by-product of steel production, still contains 5 - 10 % metal, and the alljig®-jigging machines separate out this valuable metal for metallurgical reprocessing. The other product is metal-free slag that can be used as aggregate. As raw materials are becoming increasingly scarce, there is a growing trend toward economical processing of by-product slag from ferrochromium, ferromanganase and stainless steel production. In turn, there has been a noticeable spike in demand for alljig®-jigging machines, particularly in Northern and Eastern Europe. Within the last five years, allmineral has increased its market share there considerably – and it looks like things will only get better.

**alljig®-jigging machines**

On September 8, 2010 the residents of the town of Tornio on the Finnish-Swedish border were treated to a special visit from Mauri Pekkarinen, the Finnish Minister of Economic Affairs, and the Senior Vice President of OUTOKUMPU. Both attended the official opening ceremony for the state-of-the-art processing plant at the largest stainless steel plant in Europe – which is also the biggest employer in the region.

TAPOJÄRVI will run the new plant that makes it possible to extract the last bit of valuable metal from stainless steel slag. Air-pulsed alljig®-jigging machines are the core equipment of this process, and take advantage of gravity by using the difference in metal and slag density to efficiently separate the two. These machines from Germany are designed for capacities of 50-100 tons per hour, while efficiently sorting particles ranging in size from one millimeter to 32 millimeters.
The Finnish corporate group Outokumpu is one of the largest producers of high-quality stainless steel worldwide. Its yearly melting capacity is around 2.5 million tons, and its rolling capacity for warm and cold strip, long products and quarto metal sheets is just under 2 million tons. The Finnish plant in Tornio is the affiliated group’s largest factory, and is unique in that it has the only fully integrated production line.

The aforementioned production line starts in the EU’s only chromium mine in Keminmaa, where approximately 200,000 tons of lump ore and 400,000 tons of fine concentrate are produced every year. The steel plant has two production lines: one with 100 tons and the other with 150 tons and converters in which the melted ferrochromium is processed with steel scrap. The warm rolling factory produces steel with widths ranging from 1 to 1.6 meters and with a thickness of up to 12 mm. Most of the coils made there are then turned into acid-resistant stainless steel sheets and plates at the cold rolling factory for customers all over Europe.

Due to the high separation density necessary, the alljig®-jigging machine is in many cases the only economical solution for producing high-quality metal that can then be directly reprocessed metallurgically. In addition, the cleaned slag can also be sold as valuable aggregate for concrete or road construction.

In the first half of the decade, there was a great demand in Western Europe and Africa for allmineral’s innovative processing technology, but currently the spotlight is on countries in the CIS.

Initially, allmineral set up two lines, each with two alljig®-jigging machines, for ferrochromium slag processing at the Russian metallurgical plant Cheliabinsk (one of the largest in Europe). Their throughput rate is 20 resp. 40 tons per hour and machine.

Now allmineral has received an order for two alljig®-jigging machines to be used for upgrading the raw materials enrichment for ferrochrome-production, the chromite ore itself. And following their first order for an alljig®-jigging machine in 2007, another chromium ore processing plant, owned by the Kazchrom company in Chromtau, Kazakhstan, has just ordered another one.

Within a short amount of time, twelve alljig®-jigging machines for slag processing have been put into operation: two in Belgium, four in South Africa, four in Russia and two in Finland. In addition, there are also the aforementioned four alljig®-jigging machines for chromite ore beneficiation for clients in Russia and Kazakhstan. In total, allmineral has supplied over 400 alljig®-jigging machines around the world, where they are used to efficiently sort not only slag, but also coal, ore, gravel, sand, crushed stone and recycling materials.

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It took them 5 years - from the first industrial unit to the biggest WHIMS ever built. And once again the Itaminas Mine in the heart of the Brazilian iron quadrangle in the state of Minas Gerais is the place to be. Where everything started in 2005 with a 120 tph gaustec 3200 the new Mega- WHIMS gaustec® GX 3600 went into operation in July this year, at a capacity of 700 tph. Not by coincidence again the area of one of the largest iron ore deposits in the world became the birthplace of this new class of giant magnetic separators, where huge mining activities require huge equipment capacities.

gaustec®-GX 3600

From the very first moment up to now gaustec is convincing the customers with simple but intelligent solutions, from operators for operators. The implementation of numerous improvements to the well known JONES- WHIMS concept were honored by the market. Easier maintenance, less energy consumption as well as more flexibility by means of more parameters to adjust, i.e. better performance, led to more than 50 gaustec®- WHIMS sold in five years only.

And now with the new model capacities per unit have doubled at almost the same footprint, the same weight, the same energy consumption and the same efficiency, of course:

The new gaustec®- GX 3600 with capacities from 360 to 800 tph¹)

At the Itaminas plant the new gaustec®-GX 3600 is fed with hematite iron ore < 1 mm with a feed grade of about 54 % Fe and 23 % SiO2 at a rate of 700 tph, 50 % solids. The product of this cobber stage is further upgraded in a second, already existing gaustec®-G 3600 to a final product of plus 66 % Fe and less than 3.0 % SiO2. The tailings of the cobber stage are fed to a gaustec®- GHP 150, which works as a scavenger, producing tailings with about 18 % Fe and 60 % SiO2. With the future introduction of a grinding circuit for better liberation it is expected that the iron in the tailings can be reduced to less than 10 % Fe, since by now only natural iron ore fines are processed.

¹) capacities are approximate and may vary depending on specific conditions.
In addition to the general features of gaustec®-WHIMS like

- Independently adjustable magnetic fields of the rotors of up to 15,000 Gauss
- Easy access to rotors for maintenance
- Controlled feed distribution through improved feed box design
- Optimized spray boxes for product washing of higher efficiency at less water consumption

The gaustec®-GX 3600 offers even more technical and economical advantages:

- Lower specific CAPEX and OPEX per ton of feed
- Less ancillary equipment required
- Simplified processing flow sheet and plant layout

That’s why the X in the new gaustec®-WHIMS not only symbolizes the new pole arrangement but leads the way to increased benefits for the mineral industry by making use of the high capacity gaustec®-GX technology.

¹) figures for iron ore, depending on feed characteristics, to be confirmed by test work

about allmineral:
allmineral belongs to the leading suppliers of processing plants and equipments for the mining industry worldwide. With its superb technologies the Duisburg based company is well known as a specialist for the processing and separation of coal, ore, slag, gravel and sand as well as various secondary raw materials. Around the globe more than 400 alljig®-wet jigs, 100 allflux®-fluidized bed separators, 60 allair®-dry jigs and 50 gaustec®-WHIMS are installed.
Northeim/Tianjin, October 18, 2010. The ContiTech Conveyor Belt Group, Northeim, is acquiring the conveyor belt operations of Tianjin Xinbinhai Conveyor Belt Co., Ltd., Tianjin. The relevant agreements were signed in China today. With a workforce of around 200, the company produces mainly conveyor belts for metal and cement processing and other sectors of industry at its plant in Tianjin, a port city situated 120 kilometers southeast of Beijing. “This move gives us a new market in an up-and-coming region and strengthens ContiTech’s position in China,” says Hans-Jürgen Duensing, general manager of the ContiTech Conveyor Belt Group. “We already manufacture conveyor belts for industrial applications at a number of locations worldwide. Now we can supply the Chinese market with products made right in the country.” Both sides have agreed not to disclose the purchase price.

ContiTech has been active in China already for 30 years. It currently produces hose line systems, vibration components, air springs, surface materials, conveyor belts, drive belts an coated fabrics locally at nine modern production plants and is thus able to very successfully serve the needs of automakers, machine and plant engineering and construction, mining, the printing industry, and rail transportation. ContiTech presently has 1,800 employees in China.

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The ContiTech AG

With sales of approximately €20 billion in 2009, Continental is among the leading automotive suppliers worldwide. As a supplier of brake systems, systems and components for powertrains and chassis, instrumentation, infotainment solutions, vehicle electronics, tires and technical elastomers, Continental contributes to enhanced driving safety and global climate protection. Continental is also a competent partner in networked automobile communication. Continental currently employs approximately 143,000 in 46 countries.

The ContiTech division holds a global market leadership position for many non-tire rubber products and is a specialist in plastics technology in the non-tire rubber sector. The division develops and produces functional parts, components and systems for the automotive industry and other important industries. The division has around 25,000 employees. In 2009, it achieved sales of approximately €2.4 billion.
First gearless drive system for a conveyor outside Germany

ThyssenKrupp Robins of Greenwood Village, Colorado, USA, has received the order to deliver an overland conveyor system for the Antapaccay copper mine in Peru. The end user is Xstrata Copper, a copper producer. ThyssenKrupp commissioned the Siemens Industry Solutions Division for the supply of the electrical drive system. This will be the first installation of a conveyor system with gearless drives outside Germany. In comparison to conventional drive solutions, these drives have not only a higher efficiency, availability, and reliability, but also lower maintenance requirements. The conveyor system is due to be commissioned in 2012.

The overland conveyor in Xstrata’s Antapaccay copper mine will transport ore over a distance of some 6.5 kilometers from the mine to the processing plant. The belt will be 1,372 millimeters wide, travel at 6.2 meters per second, and is designed to transport approximately 5,260 tons of material per hour. The Siemens drive system for the overland conveyor comprises of two slow-speed synchronous motors — each with a total power of 3,800 kilowatts — and the associated Sinamics SL150 cycloconverters. Each motor is connected directly to the drive pulley.

This gearless drive solution has a number of advantages over the combination of high speed motor and gearbox usually used on conveyor systems. The size of the motor is...
not limited by the size of gearbox available, thus eliminating the necessity to install multi-motor drives. The power required to drive a belt can be provided by just one drive per belt pulley. This enables the size of the electrical room to be reduced, saving space and weight.

The elimination of a whole series of mechanical and electrical components increases the reliability and efficiency of the overall system by between three and four percent. The maintenance requirements of the drive system are also substantially lower. Gearbox maintenance work alone can amount to up to five percent of the original investment volume – each year. Lubrication and gearbox cooling systems, together with their maintenance, are also obsoleted for this solution.

The gearless drive system for the Overland Conveyor System in the Antapaccay mine is the second of its type. The first conveyor system to run with gearless drives was installed in 1986 by ThyssenKrupp (formerly O&K) and Siemens in the Prosper-Haniel Mine belonging to Deutsche Steinkohle AG, and it achieves an availability of over 98 percent.

Xstrata Copper, based in Brisbane, Australia, is part of Xstrata plc, and operates mines and production plants in Argentina, Australia, Chile, Canada and Peru. The company is the fourth largest copper producer in the world, and has a production capacity of almost one million tons per annum. The Antapaccay copper mine in the south of Peru is Xstrata’s latest project. As from 2012, it is scheduled to produce some 160,000 tons of copper concentrate per annum.

ThyssenKrupp Robins is the US subsidiary of ThyssenKrupp Fördertechnik. The company specializes in the design and supply of technologically advanced conveyor applications.

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The ThyssenKrupp Fördertechnik GmbH
is part of the Business Area Plant Technology of ThyssenKrupp AG. With more than 2,700 employees worldwide ThyssenKrupp Fördertechnik is one of the leading suppliers of plants and systems for the mining, processing and handling of raw materials and minerals. Our equipment is used in open-pit mines, stockyards, port terminals, power plants and quarries throughout the world, constantly setting new standards. Innovative concepts, decades of expertise and a global presence enable us to provide expert advice, planning, engineering, design, construction, delivery, installation, commissioning and after-sales service.
For decades HAVER & BOECKER has been offering various refined screening systems that have the right configuration and meet the highest demands for quality, performance and long life and that can be used for practically every application.

The long life of HAVER screening machines was once again recently demonstrated when two screening machines manufactured in 1940 were overhauled at the Machinery Division in Münster, and then sold to two German customers with very specific applications.

Both machines were equipped with new motors, thus increasing speed and energy efficiency. One of the machines was outfitted with a PS screen, and the other was rebuilt with side-tensioning cross-pieces and tension rails.

In times when companies are still recovering from the economic crisis, HAVER & BOECKER is focussed on retrofitting solutions. Depending on the extent of the overhaul, the expense of a complete machine modernization is in the range of 20 to 60% of the cost of a new machine. This is how HAVER & BOECKER can extend the lifetime of a machine and increase productivity and economy for customers.
Recently HAVER & BOECKER carried out a pilot project in Kaisheim, Bavaria at the Gandl Natursteine GmbH company. It was the first time a HAVER-FFS machine was used for filling natural stones.

The family-run company of Gandl trades in natural stones, and processes them. The variety of natural stones is broad: granite, porphyry, quartzite, quartz sandstone, marble, slate, dolomite, shell limestone, basalt and limestone belong to its product range. Now these are being packed by a HAVER FFS Alpha. It’s the heart of the complete packing system. Material feeding is done by a heavy conveyor, followed by washing of the stone. At the end, there’s a robotic palletising unit with film packaging, which includes online printing and a complete pallet gathering lane.

The challenge faced in this system was to generate a concept and a functionality that allowed the fully automatic filling and packing of fine sand, pea-stone, fine gravel and coarse natural stone (up to 60 mm) via selectable sort adjustment. With it, there’s comprehensive film and bag size selection that allows the filling of various premium quality products into transparent film packaging.

Under the lead-management of HAVER & BOECKER and project manager Sebastian Südhoff, the family-owned machine builder in Oelde, Westphalia developed together with film manufacturer RKW and BEUMER a packaging concept that fulfils the highest demands for this new market segment.

Customer requirements for greater flexibility, ease of operation and optimum packaging quality were fulfilled to the fullest extent.
The guiding themes of this year’s Construction Equipment World Economic Forum (CEWEF), which was conducted mid-September in Brussels, were comprehensive cost-estimates in machine operations, economic aspects of environmental protection and occupational safety, as well as certain developments in the international construction machinery market.

For the third time already, the Groeneveld group had invited high-level decision makers from the producing and construction industry, relevant service industries, as well as machine manufacturers and suppliers for exchange of experiences. Over 100 participants from Europe and Overseas accepted the invitation and unanimously acknowledged the CEWE concept as a valuable complement to professionally institutionalized industry meetings and the hectic trade fair communications, which leave little space for exchanges between colleagues.

**CEWEF establishes itself**

The CEWEF, the Construction Equipment World Economic Forum, was first conducted in 2008. Along the lines of corresponding political models, CEWEF aims at promoting the dialogue between key stakeholders in operating industries, suppliers and service providers beyond competition boundaries and set agendas. CEWEF was initiated by the Dutch Groeneveld group. With its globally marketed OEM and endcostumer oriented solutions for lubricant handling (engine oil control, central lubrication) and security solutions (return control), the enterprise itself has been directly involved in many sectors of the construction and construction material industry, at the intersection of technological requirements, operation and security requirements, as well as in requirements with regard to application technologies.

Following over 80 participants in the opening in 2008, sixty guests in 2009, and more than 100 experts from over 15 countries in this year, CEWEF has established itself as an important information platform. Again the biggest group of participants were responsible decision-makers of multi-national operating companies, responsible for acquisition and operation of big fleets of machines. Among others, the big international concrete manufacturers, as well as national group companies from the mineral material, construction material production and recycling were represented. They had the chance to meet high-level representatives of international machine manufacturers and suppliers, as well as representations of industry interests. The majority of participants used the eve of the actual CEWEF seminar for informal exchange.
The consistently positive reactions of all participants encourages the Groeneveld group to continue the CEWEF series. The next Construction Equipment World Economic Forum was announced for fall of next year, again to be held in Brussels.

Integral Information

In the CEWEF seminar, a total of eight individual articles dealt with specified guiding themes, “Cost-effectiveness in machine operations”, “Safety” and “New developments in the construction machinery market”. This thematic structure ensured the practical relevance of all articles of the highly experienced speakers from the construction equipment and supply industry, as well providing ample opportunities for questions and suggestions from the plenum of experts. All articles can be accessed under www.cewef.com.

In a way the basis of the profitability studies was a recourse to the „Total Cost of Ownership“-Model of the preceding CEWEF events. Apart from the fixed costs of purchase, financing and residual value, this calculation of lifecycle costs of a construction machine also includes variable operation costs like personnel, fuel, maintenance and servicing, as well as additional equipment and spare parts. All speakers agreed to the fact that while the model is quite complex, it offers high potential for long-term savings, which can be converted into effectively traceable production costs (e.g. costs per ton), in case of exact (pre-) calculation.

The range of topics with regard to safety predominantly dealt with the increasing requirements of occupational safety and health, but it also dealt with higher order aspects of sustainability of climate and environmental protection. The discussion here was mainly centered around economical effects of development and production.
of construction machines, as well as on the operation practice. A sensible balance between the greatest possible safety and reasonable operational feasibility should be aimed at.

The new developments in the construction machine market were not only discussed in the innovation examples of the represented manufacturers and suppliers. The introduction of the revolutionary vehicle concept ETF, as well as the activities of the Chinese construction machine manufacturers and suppliers, which increasingly operate internationally, offered concrete perspectives.

**Challenges of machine manufacturers**

Shortly before the tightened exhaust gas regulations Tier4i/EU-step IIIb come into effect, which is from 2011, the representatives of the machine manufacturers informed about the status and perspectives of reduction of pollutants. Dirk Stukkens, corporate client agent of Komatsu Europe, and Bill Law, marketing expert of the Volvo-Group, oriented the participants to new drive concepts in the construction machine sector. In addition to developed, multi-level emission control systems for conventional combustion engines, many manufacturers are already working on hybrid systems, which are meant to significantly lower the fuel consumption, as an indispensable prerequisite for the improvement of the CO2 point balance.

Through cost examples on the basis of TCO models, Dirk Stukkens demonstrated the extent, to which the operator himself can influence the cost-effectiveness of his machines. Thus a timely renewal of the vehicle fleet can avoid disproportionally increasing maintenance costs. The avoidance of idle running times is also an important theme: According to Stukkens, fuel expenses account for up to 40% of the life cycle costs of a construction machine, and as a result the saving potential through targeted or early switching off of the motor in waiting phases is high. In case this is consistently practiced, the sales value of a machine increases due to less documented operating hours.

Bill Law also believes that correct operation of the machine is an important prerequisite for cost-efficient operation. In this endeavor Volvo Construction Equipment supports the operator with specific computer analyses of the actual operation practice and special training programmes, which for example communicate fuel-efficient modes of operation during loading and driving operation.
Suitable Equipment Pays Off

Two other CEWF articles highlighted the influence of modern products of the supply industry, or the right attachment in cooperation with construction machines.

Michelin-marketing-manager Guillermo Crevatin, globally in charge of EM and industry tires, outlined the dual approach of his company in the development of tire technology for specific machine applications, again based on the TCO costing model. This includes reduction of costs through an increased lifetime and reduced costs for maintenance expenditures, but also productivity increases through specifically developed tire solutions, which correspond exactly to the respective operating requirements (high traction, low rolling resistance). In Brussels Crevatin introduced new customer service initiatives, with which Michelin supports operators for correct choice of tires and long-term maintenance.

Caterpillar’s product specialist Larry Bruell underlined the importance of the right choice and application of excavation tools for the cost-efficient operation of earth-moving machines. Not only do adequate excavation tools and the corresponding accessories ensure the productivity of dredgers and wheel loaders, but they also protect the considerably more expensive components at the booms and working hydraulics systems. With case studies on the basis of accurately documented usage fee and obtained production results, Larry Bruell demonstrated how after the change of excavating buckets, dents or blades, the efficiency of the same carrier machine dramatically deteriorated or even massive damages occurred.

Safety as a Brand

Due to elaborate technical or organizational requirements, occupational and health protection increasingly influences the costs in construction machine operations. Ralf Wetzel, general secretary of the Committee for the European Construction Equipment Industry (CECE) in Brussels, which serves as an umbrella organization of relevant European trade unions and is actively involved in the development of the EU-occupational safety directives. He presented an overview of the current EU standardization practice in the areas of occupational safety and health.
The CE sign, which regulates the entry of products into the European market, encompasses an extensively documented process, in which the machine manufacturers have to prove that they have implemented the relevant directives. Accordingly it is important to protect the CE sign and its application as a reliable “brand”. It is with operator-oriented information that the CECE is now combating the abuse of the CE sign, something which increasingly happens in grey- and reimports of new and used machines from the non-European market. Thus the association of manufacturers not only protects the safety-related investments of its members, but also protects the operators from jeopardizing the liability of their own occupational safety organization by the usage of “unsafe” machines in the sense of the EU legislation.

Quality “Made in China”

The presentations of the Chinese tire manufacturer Techking and the construction machine manufacturer was eagerly followed by CEWEF participants. The dimensions of the far Eastern boom are still breathtaking: as such the Chinese demand of EM tires corresponds to approximately 25% of the global market, and with more than 40,000 produced units per year, the construction machine manufacturer Liugong, who is also active in other product segments, in the past years turned to the globally biggest supplier of wheel loaders.

Against the background of these huge masses, the market strategies presented in Brussels by Samuel Hermansson, responsible for the European Techking business and by Luo Guobing, President of Liugong Europe, appeared all the more differentiated. In addition to the intensive expansion of their national and regional presence in the sales and, more importantly in the after sales sector, both enterprises emphasize custom-fit orientation of their products and services to higher-ranking market demands and specific costumer needs. The keys are impressive efforts in the areas of research and development, which range from working on own concepts and development cooperation with internationally leading
partners up to tailor made special solutions in the end costumer business. As such, according to Samuel Hermansson, Techking not only works on efficient tire concepts along the requirements of fuel efficiency and long machine life, but also on own tire control systems with internet connection. Furthermore Techking develops short-term special solutions for specific applications, together with and for custumers of the EM and industry sector.

According to its president Luo Guobing, Liugong also massively invests in long-term development, in close collaboration with Chinese universities and international industry partners. This process follows enormous innovative dynamics and benefits from a growing pool of highly qualified experts and product-specific transfer of know-how. The clear message is: Chinese products will not only establish themselves because of their price, but through quality.

**Dump Truck 2.0**

In presenting the new ETF mining trucks, Eddie de Jongh, CEO of the European Truck Factory (ETF), demonstrated how it is possible to bring together the lines of this year’s CEWEF conference through product innovation.

Modularly built transport vehicles are meant to revolutionize the raw material transport above 80 tons net load in open cast mines. Model programs with four performance classes up to 218 tons of net load and combined total performances in traction mode up to 800 tons with only one driver, promise new dimensions with regard to operational management and cost effectiveness. An all-encompassing electronic vehicle management not only releases the driver, but to a certain extent attends to itself. Entirely exchangeable integrated modules in the engine and gear are also meant to minimize the downtime.

The ETF concept is not only characterized by a complete turning away from the rigid two-axle dump trucks with conventional motor-gear-technique or diesel-electronic two-axle dump trucks. With the exclusive marketing as a long-lasting leasing model with comprehensive local service and availability guarantee, the manufacturer takes a new line. The first production models of ETF mining trucks will be presented in March next year.

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New Standards in Mining

HITACHI’S NEW LARGE WHEEL LOADER
IN ACTION

HITACHI WHEEL LOADERS AND HYDRAULIC DREDGERS ARE KNOWN FOR THEIR HIGH QUALITY, PERFORMANCE AND ROBUSTNESS, PARTICULARLY NEEDED IN HARD EXTRACTION OPERATIONS. THE FIRST HITACHI LARGE WHEEL LOADERS WERE INTRODUCED IN BAUMA 2010, RESULTING FROM THE ALLIANCE BETWEEN HITACHI CONSTRUCTION MACHINERY UND KAWASAKI HEAVY INDUSTRIES. AS ONE OF THE FIRST MACHINES DELIVERED TO GERMAN, A ZW550 CONVINCES IN EXTRACTION OPERATIONS.

New Hitachi Large Wheel Loader for Extraction of Natural Stone

Since July 2010 the Hitachi large wheel loader ZW550 is operating in block handling format in a South-German jura marble quarry with processing plant. Together with the system partner LOC-Matic, the front equipment was optimally adapted to the individual requirements of the quarry and the performance parameters of the Hitachi wheel loader. Equipped with hydraulic quick changing device, the ZW550 can flexibly be applied with raise sprocket for block extraction.

Often a short-term higher performance is needed during breakage of the blocks, and this performance is easily achieved by Hitachi with a pressure connection of the hydraulics. In block transport the large wheel loader convinces with highest loads. Moreover the ZW550 is equipped with an adjustable traction control, which automatically adjusts to the working conditions. The box frame, a low hinged lifting cylinder and two bucket cylinders make this wheel loader-model even more effective for application in natural stone extraction.

### Table 1: Overview of modeltypes

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<thead>
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<th>ZW330</th>
<th>ZW370</th>
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Service

It is not only because of the consulting and support by Kiesel that the quarry has decided to use Hitachi machines. Since many years Kiesel has focused on the development of system solutions. Involving clients and taking into consideration their individual demands, Kiesel product developers and system partners develop specific complete solutions. With this concept the client receives everything from one hand.

Furthermore, with its comprehensive service concept, Kiesel can guarantee non-bureaucratic and competent service. The Kiesel service team encompasses approximately 350 technicians and 50 construction machine technician trainees. This is due to the fact that for Kiesel an excellent service and extra services are at the heart of their work, in order to ensure an efficient and true process.

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The Limeworks J. Bergmann from Azendorf has upgraded its machinery with three large scale equipment from Komatsu. The machines, two crawler excavators and one dumper, which were supplied by Reif Baumaschinen, support annual extraction of approximately 350,000 tons of limestone from the two quarries in Azendorf.

“We are a company that is rich in tradition”, says Dr. Thomas Jendersie. The Mining engineer is the technical director and general manager of the J. Bergmann GmbH & Co. Since 1908 the enterprise has been mining limestone in the Azendorf quarry, approximately 20 kilometers southwest of Bayreuth. Licenses for further 50 years have been obtained. The Franken-Maxit-Group belongs to the Bergmann company, with more than eight locations in Germany and a branch in the Czech Republic. Hans-Dieter Groppweis is the managing partner of Bergman Kalk and the Franken-Maxi-Group. His grandfather Johann Bergmann has founded the enterprise more than 100 years ago in Azendorf.

Wheels must roll

Today the group employs approximately 550 staff. 200 of them work in the Azendorf location. “We are responsible for the fact that the wheels of others roll”, Jendersie explains. What he means is that other locations of the group are dependant on the supplies from Azendorf. “It must run like clockwork”, says Jendersie. Failures should not be permitted, particularly in the machinery. “Otherwise the wheels of others stop”. With regard to the production plants, as well as the machinery, product quality and high reliability of supply have highest priority.
Three heavy chain dredgers, a big wheel loader, two dump trucks and two dumpers ensure that every day 2,000 tons of limestone are loaded and transported to the primary crusher. Two chain dredgers are newly added to the machinery, a PC450LC-8/HD and a PC600-8/SE, both from Komatsu. Jendersie mentioned that “previously there have been good experiences with a used PC340”. The same applies to the new HD405-7, the second dump truck of the Japanese manufacturer, which reliably provides services in the quarry. “The machines have also convinced us with regard to fuel consumption” states Jendersie.

Hatch Developed by Supplier

Since the quarry encompasses three pits, one of which can only be accessed through a public street, the basin of the HD405-7 was equipped with a hatch specially developed by Reif Baumaschinen. In the workshops of the Komatsu retailer, with its main office in Ansbach, the cavity-faces were heightened by 20 cm. This allows for the 386 kW (525 PS) strong machine to drive fully loaded and with approximately 75 tons, without material falling down and people being jeopardized. Furthermore, each time it comes out of the quarry, the dump truck is cleaned in a few seconds in an automatic washer system. Through this the road crossing is kept perfectly clean.

The two new Komatsu chain dredgers are fully equipped for the hard work in the quarry. The PC600-8/SE has a particularly resistant Lehnstoff special bucket with a highly wear-resistant Komatsu- tooth system. It has a net weight of 3.5 t and a capacity of 3.5 m³.

A special ascent, a guard rail, and a safety guard ensure the safety of the driver and the service personnel. The water-cooled and turbo-charged diesel engine of the over 60 ton machine and the motor of the dump truck accomplishes 323 kW (439 PS) and fulfills the Tier-III-norm. The same applies to its smaller brother, the 263 kW (358 PS) strong PC450LC-8/HD.

Apart from a reinforced undercarriage and a boom, it possesses the highly wear resistant KMAX- tooth system of Komatsu, in which the spikes can be exchanged according to working conditions. Furthermore all three machines are equipped with the KomtraxTM machine detection system. It provides information about the location and status of the machines via satellite and internet, and thus ensures an efficient fleet management. This does not only help to prolong the operational readiness, but also the service life of the machines.

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Komatsu:
The trough of the HD405-7 is equipped with a hatch specially developed and produced by Ralf Baumaschinen. In the workshops of the Komatsu retailer, with its main office in Ansbach, the cavity-faces were heightened by 20 cm.
Regional Waste Management and Recycling Company builds on Flexibility in Operation with the Komatsu Mobile Dredger PW-180-7!

In September the Heidemann Recycling GmbH & Co. KG, a small business with its office in Eisfeld/Thueringen made a decision for the Komatsu Mobile dredger PW180-7. The dredger is not only the ideal companion for the civil engineering and road construction, but also in many other sectors like for example in disposal, recycling and in demolition.

For 20 years, the family company Heidemann, a certified recycling company in the South Thueringen region and with 25 qualified staff, has been well known for processing and recycling. From the very beginning, trust of the clients has been the priority for Dag Heidemann, the managing director. The trust in the machines and the responsible Komatsu supplier “Schlüter für Baumaschinen” is another important point in the course of business of the Heidemann company, because the success of qualitative work is also built on that.

In the run-up, at the beginning of the year, already a Komatsu wheel loader WA 470 LC-6 was added to the modern machinery. It was the first Komatsu for Heidemann, and it is used for transporting the material processed by the PW180-7 from A to B into the crushing plant.

The PW180 is equipped with a concrete cutter to crush concrete parts like for example railway ties. Due to its quick change system the PW180-7 is an equipment carrier for many fields of application. It is noteworthy that the 18 mobile dredger is one of the most stable machines of its category – a plus point in the decision to purchase. Ergonomically formed operating devices like for example joysticks with proportional control and a particularly low noise pressurized cabin with automatic air-conditioning create an agreeable work place for the driver. Without further ado, roof protection and safety guards for front screens are available for the breakage. The driver has the option to adjust the oil flow of the auxiliary hydraulics by himself. Furthermore, various pipings and pre-settings ensure a quick change of equipment. Thus the hammer,
concrete crusher, demolition and sorting tongs, as well as the chisel can be changed in seconds.

With regard to accessibility for maintenance, the PW180-7 is constructed in a way that all the maintenance points are easily accessible. For the PW180-7 also, Komtrax™ is available in series. The satellite-supported machine detection system always has an eye on the machines, even in the case of continuously changing construction sites and drivers. Komtrax™ makes it possible to determine the exact location of the machines through the internet and to obtain exact data, e.g. about fuel consumption, maintenance intervals and operating hours. This allows for an accurate and efficient planning of usage of the machines, increase in the operating life of the machines, as well as decrease in downtimes through forward-looking planning.

As such the PW180-7 is best equipped for the recycling operation of the Heidemann company and convinces both drivers and clients in daily operation.

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Technology Days 2010 at new Kleemann plant:

State-of-the-art machine technology and tomorrow’s construction methods were the focal points of the Wirtgen Group Technology Days in September 2010. The Wirtgen Group with its global network of 55 subsidiaries and more than 100 dealers had invited contractors from the road construction and processing industries to Göppingen. More than 2,600 visitors from over 80 countries gathered at the new Kleemann plant where they not only toured the world’s most advanced production plant for crushing and screening equipment but also discovered the innovative technologies of the Wirtgen Group live and right up close.

During the two-day event, the Wirtgen Group presented customers with a multi-faceted offer of expert information and a great variety of machine demonstrations. Being the third event of this kind, the Technology Days have established themselves as an international meeting place of the industry. Visitors arrived from all parts of Europe – from the North Cape all the way to Andalusia. Several hundred visitors from Asia, more than 250 visitors from North and South America, as well as numerous customers from the Middle East, Australia and Africa also seized this unique opportunity. Live demonstrations of machines from all divisions of the Wirtgen Group were undoubtedly the highlight of the programme, which was complemented by expert lectures, a comprehensive machine exhibition and a tour of Kleemann’s new main plant.

Kleemann presents most advanced plant in the industry

Kleemann GmbH, the renowned manufacturer of crushing and screening plants, has been a member of the Wirtgen Group since 2006. This course of action has enabled the group of companies to specifically broaden its product portfolio. As both a clear commitment to Germany as a manufacturing base and a strong sign of confidence to its workforce, the Wirtgen Group has been investing, since 2008, in the construction of a new main plant not far from the old production facilities. Whilst other companies in the industry drastically reduced their investments and put new construction projects on hold in 2008 and 2009 on account of the global economic crisis, a state-of-the-art production plant was put up in Göppingen which offers ample space for future developments. This kind of far-sightedness, along with the courage to make anti-cyclical investments, is a hallmark of the strategy pursued by the Wirtgen Group. The consistent and continuous expansion of the German main production plants in recent years has provided Wirtgen, Vögele, Hamm and Kleemann with four state-of-the-art production sites that offer perfect preconditions for the development, engineering and production of state-of-the-art construction machinery and plant.

Kleemann’s new main plant is the foundation for expanding the Mineral Technologies line of business which offers an extremely promising potential for growth on a global scale. The site, which extends...
across an area of 125,000 square metres, was open to customers for the duration of the Technology Days 2010, allowing visitors to gain an impression of the high level of vertical integration, short distances inside the plant and high precision applied in the production of the crushing and screening plants. During their tour of the plant, the visitors witnessed how individual components are fabricated, plants are assembled and subjected to quality control testing.

Managing Director Dr. Gerhard Schumacher views the new plant as an “ideal basis for future success. We have laid the technical foundations for a highly qualified workforce to supply the international markets with high-quality crushing and screening plants.” The Technology Days have given Kleemann GmbH a unique opportunity to present its understanding of quality in manufacturing to industry peers. “Customers were given the opportunity during the Technology Days to discover both our high quality standards in manufacturing and the solutions and technologies we offer. Our visitors will carry this message to their home countries in all parts of the world, and in the medium term it will certainly contribute to increasing our market share,” says Dr. Schumacher, summarizing the long-term effects of the event.

Versatility and flexibility are vital hallmarks of state-of-the-art construction machines. How customers benefit from them was demonstrated by the modification of several machines during lunchtime which, at first glance, was not spectacular at all. Cameras followed the modification work and transmitted live images to a screen, thus enabling the visitors to watch each and every move. Without using special equipment, the technicians needed no more than two hours to change the milling drum in a W 200, alter the ballasting of a GRW 280 pneumatic-tyred roller and convert the Super 3000-2 asphalt paver from a rigid to an extending paving screed. This demonstration was impressive proof of the practical efficiency of the machines and their easily replace-able modules.

Road construction and processing technologies live and up close

The audience closely followed the live demonstrations of machines operating in a model limestone quarry and rehabilitating the surface course of a road. Machine developers, product trainers and sales experts of the manufacturing companies explained the live operation of the Kleemann crushing and screening plants, Wirtgen 2500 SM surface miner, the latest generation of Wirtgen large milling machines, the world’s largest asphalt paver from Vögele as well as the entire range of new asphalt rollers from Hamm.

Dr. Gerhard Schumacher, Managing Director of Kleemann GmbH, was extremely satisfied with the event: “Hosting the Technology Days 2010, Kleemann has made a lasting, positive impression on the road construction and processing industries.”

The Wirtgen Group presented state-of-the-art technology in the fields of road construction and rock mining, thus enabling the visitors to catch a glimpse of the “construction site of tomorrow”.
Processing concrete, milling concrete, producing cold mix, paving and compacting a hydraulically bound base layer, creating concrete profiles – the second demonstration focused on linking these technologies. From Kleemann’s brand-new Mobirex MR 110 Z EVO mobile impact crusher with metal separator, the crushed demolished concrete was directly fed into a Wirtgen KMA 220 cold recycling mixing plant which used it to produce material for a hydraulically bound base layer. Paving was carried out by the Vögele Super 3000-2 paver, and the paved layer was then compacted by the latest generation of Hamm tandem rollers and pneumatic-tyred rollers. During the final stage of the demonstration, Wirtgen presented the new SP 15 slipform paver which paved a concrete profile in a live operation.

Hands-on technologies in theory and practice

After the end of the live demonstrations, the visitors poured onto the site to have a closer look at the layers, milling cuts and construction materials produced by the various machines. The great variety of technologies and products offered new information and insight gains for everyone present. “We are milling contractors, and so our focus is mainly on the milling machines. All the same, the demonstrations of crushers, pavers and rollers are of great interest to us as they enable us to learn more about the innovations in the preceding and following project phases,” declared visitors from Sweden. Not so for a contractor from Colombia. He has worked with a wide variety of Wirtgen Group technologies for many years and was particularly interested in the large Vögele paver and feeder models. A German quarry operator expressed his major benefits as follows: “The live demonstrations were very impressive. They have reinforced my trust in the brands and products of the Wirtgen Group because I could see for myself that the machines do in fact perform as promised.”

Three Kleemann specialists presented the latest products and projects in a series of highly interesting expert lectures. They conveyed a clear message: Kleemann will work out tailor-made and economical solutions for each project in close cooperation with the customer. Separate short presentations held in the outdoor area additionally enabled visitors to discover the outstanding features of the latest Wirtgen, Vögele, Hamm and Kleemann machines. The sound professional explanations given were just as convincing as the live machine demonstrations the customers had witnessed.
The machine exhibition on Kleemann’s company site in Göppingen was the ideal background for an in-depth exchange of ideas and industry talks that were held in between the various expert lectures and presentations. All product divisions from the “Road and Mineral Technologies” were on display, headed by the latest innovations. Wirtgen had even brought two world firsts: the new SP 15 and SP 25 slipform pavers.

“Close to our customers” – everyone present in Göppingen during the two-day event sensed that the Wirtgen Group’s claim is not merely an empty promise but a practiced habit in day-to-day business. It is doubtlessly one of the reasons why the visitors are eager to attend again next time.

Following the live demonstrations, customers had an opportunity to get a closer look at the demonstration site. The freshly paved concrete profile, which had been produced by the new Wirtgen SP 15 slipform paver in a live operation, met with particular interest.
CAT® 390D L DELIVERS STRONGER PERFORMANCE, RUGGED DURABILITY, MORE OPERATOR AMENITIES AND IMPROVED SERVICEABILITY

THE NEW 90-METRIC-TON CAT® 390D L HYDRAULIC EXCAVATOR, WHICH REPLACES THE 385C L, INCORPORATES A REFINED DESIGN THAT PROVIDES GREATER HYDRAULIC POWER, STRONGER STRUCTURAL COMPONENTS, ADDED SAFETY AND CONVENIENCE FEATURES, PLUS IMPROVED SERVICEABILITY. THE NET RESULT IS A MORE PRODUCTIVE, MORE DURABLE, MORE EFFICIENT MACHINE THAT IS COMFORTABLE TO OPERATE AND CAN TAKE ON THE TOUGHEST JOBS IN A RANGE OF HEAVY CONSTRUCTION AND MINING APPLICATIONS.

Engine and hydraulics

Powering the new 390D L is the 18.1-liter Cat C18 ACERT® diesel engine, which is EU Stage IIIA and U.S. EPA Tier 3 compliant and rated at 523 net horsepower (390 kW). The C18 features advanced electronic control, precise fuel delivery and refined air management for optimum performance, fuel efficiency and emissions control. The engine’s torque characteristics allow full power at maximum rpm, resulting in efficient hydraulic pump operation and positive hydraulic response. Refinements in the crankcase, cylinder heads and proprietary MEUI (Mechanical Electronic Unit Injector) fuel system provide enhanced performance and durability for the C18.

Design enhancements in the 390D L’s implement hydraulic system allow the new model to deliver significantly greater digging and lifting forces than its 385C predecessor. Main relief pressure in the new model’s implement circuits has been increased to 35000 kPa, up nearly 10 percent from that of the 385C. This increase in operating pressure results in 9% digging force increase. Increased breakout force promotes faster trenching and loading cycles plus stronger performance at the quarry face. In addition, lifting capacity over the end is increased by 14 percent with over-the-side capacity up nearly 14 percent—the result of stronger hydraulics and a heavier counterweight.
Also new in the 390D L’s implement hydraulic circuits are electrically controlled regeneration valves, which assure rapid, positive response from the boom and digging arm cylinders while also significantly improving overall hydraulic efficiency. The resulting benefits include quicker cycle times and estimated fuel savings of more than 2 percent.

A universal quick-coupler circuit is available for factory installation and is compatible with both dedicated and pin-grabber-type couplers. The system features an offset lifting eye and easy-to-use controls.

**Structures and undercarriage**

An improved undercarriage for the 390D L features redesigned links that operate with lower stress, forged idlers for improved durability and heavy-duty track rollers and carrier rollers. In addition, the recoil spring has been lengthened, giving the recoil mechanism greater impact-absorbing capability to protect the undercarriage system from shock loads.

To accommodate the higher digging and lifting forces generated by the 390D L, the carbody (the structure mounting the machine upper to the track assemblies) is fabricated with thicker reinforcing plates at critical locations. Complementing this change are thicker plates at the boom-foot mounting in the upper frame as well as thicker reinforcing plates in the rails and bottom pan to accommodate the heavier counterweight.

The counterweight weighs 12.4 tonnes, making it slightly more than 6 percent heavier than the 385C’s counterweight.

Booms and digging arms also are stronger, the result of thicker material used in their fabrication and an improved welding process. To assure continuous welds, with no craters at the start and stop of the weld pass that can induce stress, “runoff” tabs are first tacked at each end of the seam between plates being joined. When the weld is made, it begins on the first runoff tab, continues across the seam, and ends on the second runoff tab. The runoff tabs are then removed, leaving a consistent weld bead across the seam. When completely fabricated, booms and digging arms are placed in a heat-treat oven to relieve any welding-induced stress.

**Operator comfort and convenience**

The 390D L’s operator’s station is spacious, quiet and comfortable with commanding visibility.
The cab is pressurized to keep out dust, and the filtered ventilation system combines with automatic climate control to maintain a constant, comfortable environment. The monitor provides full-color graphic displays with comprehensive machine information presented in either an English or ISO format.

The monitor provides fluid level checks when the engine is started, can list approaching service intervals and can display real-time fuel consumption information numerically. Flexible power modes—high power or economy—allow the operator to adjust machine performance to the task. Both modes provide the same digging forces, but the economy mode allows the machine to work with fuel-saving efficiency when production requirements are less critical.

For the operator’s convenience, height of the control-lever consoles is adjustable, and the response and modulation of the electro-hydraulic joysticks can be adjusted through the monitor. The control-pattern changer, also accessible through the monitor, allows the operator to select preferred lever functions. In addition, the monitor displays images from the 390D L’s optional rearview and Wide Area Vision System cameras, the latter mounted on the boom or side of the machine.

To diminish heat and noise in the cab, the hydraulic control valve, pumps and reservoir are positioned on the right side of the machine away from the operator’s station. Standard halogen lights provide exceptional jobsite illumination but can be replaced with optional High Intensity Gas lights on the boom and upper cab if more illumination is required. Cab Lights are time delayed to allow safe exit from the machine at night. And to maintain good communication, the 390D L’s cab is two-way radio ready.

Service Improvements

The 390D L uses an electric fuel priming pump, which simplifies filter changes. A dual-element air cleaner with a double radial seal is standard. All filters, except for the high-pressure fuel filter, are accessible from the left side of the machine. Service safety features include a 24-volt service light receptacle and wider, 500-mm walkways that provide sure-footed access to maintenance points.

To facilitate easier, environmentally sound routine maintenance, the 390D L is equipped with protected, valve-controlled fluid-drain ports and self-contained hoses for fuel, coolant and lubricant systems. Easy-to-change spin-on filters are used in the fuel and lubricant systems, and pressurized fluid sampling ports (in all pressurized fluid circuits) assure reliable fluid samples.
An electronic warning system alerts the operator if the air filter or hydraulic filter is approaching restriction limits.

The Electronic Power Control (EPC) has been relocated from the cab (its position in the 385C) to the 390D L’s air cleaner compartment, allowing the cab floor to be washed without risk of damage to the EPC. For further reliability, the EPC and its electrical terminals are weather-proof.

Caterpillar
For more than 80 years, Caterpillar Inc. has been building the world’s infrastructure and, in partnership with its worldwide dealer network, is driving positive and sustainable change on every continent. With 2009 sales and revenues of $32.396 billion, Caterpillar is a technology leader and the world’s leading manufacturer of construction and mining equipment, diesel and natural gas engines and industrial gas turbines. More information is available at www.cat.com.

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* At 6.1-m radius, 6.1-m depth, w/10-m boom, 4.4-m digging arm and 900-mm shoes
The commercial operation of the Ceneri Base Tunnel is planned to start at the end of 2019. Upon its completion it will allow high-speed rail and heavy freight trains, both of which were not possible in the existing steep track over the mountain of Monte Ceneri.

Tunnelling on the main 2.3 km long access adit to the cavern already started in 2008, using a 9.7 m diameter Robbins TBM. The construction site for the two railway tunnels will be in full swing in autumn 2010. Excavation, support and lining work should be finished in 2016.
The tunnel contractor consortium Condotte Cossi had a long hard look at several manufactures who were bidding for the lucrative machinery order. They opted for the Swiss Cat dealer Avesco who was able to offer the most of the needed machinery to complete the excavation of the twin tunnels. For the Ceneri Base Tunnel Project Avesco, Italian Cat dealer CGT and Zeppelin, the Cat dealer from Germany, are working together. Another plus for Avesco was the experience they gained with supplying and maintaining machinery for the Sedrun section of the Gotthard Base Tunnel. As the “Bautechnik” branch of Avesco is the official dealer for Sandvik, they were able to offer a complete package including eight drilling jumbos, four underground wheel loaders, eight compact radius tunnelling excavators, eight hydraulic hammers, eight special wheel loaders and some support equipment.

The Cat 314D LCR and 328D LCR excavators, customized by the dealer for tunnelling purposes, are a rare species among the large Cat excavator family. While the track frames and the upper-structures look familiar, both booms and dippers are unconventional in shape and size. A further feature on both excavators is the heavy-duty dozer blade fitted to the carbody. Strong covers protect the top side of the blade cylinders. It ensures outstanding stability and also enables any levelling work to be undertaken. While clearing the tunnel crown and vertical face from loose rock, the blade at the rear prevents the machine from creeping backwards. Like every other machine that works on the Ceneri tunnelling site, the eight compact radius excavators are equipped with two fire extinguishers, one in the cab and one on the outside of the excavator.

To change a standard Cat compact radius 314D LCR into a 15.5 tonne tunnelling excavator, Avesco invested a lot of man-hours. What first pops up in one’s eye is the short main boom. The mechanics removed the original 4.65 m long booms and the welders built new 2.01 m long ultra short booms. Except for the strong cylinder cover, the stick and the hydraulic quick coupler are standard. Besides the vicious-looking ripping claw, a 1330 kg Sandvik BR2266 hydraulic hammer and a standard backhoe bucket for loading purposes can be attached to the quick coupler. To protect the operator, a Falling Object Guarding System (FOGS) was added to the cab.

With an operating weight of 43.5 tonnes the Cat 328D LCR is so far the only short radius tunnelling excavator in the 40-tonne-class. The tail swing radius of just 1.90 m only marginally protrudes over the undercarriage. The 328D LCR shares the upper-structure of the 329D and the undercarriage of the 336D L. Its specially designed boom with torsion resistant cross-sections is built by the German Cat dealer Zeppelin. The main boom of the 328D LCR pivots 45 degrees to the left or right of centre. This tilting mechanism allows the excavator to reach maximum operational flexibility in narrow tunnel profiles. The bucket stick is 4.65 m long and can be equipped with all kinds of buckets, hammers and drum cutters. Avesco delivered four 2370 kg Sandvik BR3088 hydraulic breakers for the Cat 328D LCR tunnelling excavators.

For the loading and shovelling duties within the narrow connecting galleries between the two single-track tunnels, Avesco modified four Cat 938H wheel loaders. To make them tunnelling proof, the mechanics shortened the fenders on each side and removed parts of the rear fenders. The maximum width of the loader is now 2.6 m. To better protect the operator from falling rocks, the welders...
fixed a second roof on the cab and a front windshield guarding. A moving cover prevents damage to the dump-cylinder and heavy steelbeams on the counterweight protect the radiator from side-impacts. The sidedumping buckets were built up to specifications by the Swiss based attachment specialist Ullmann. Like every other Cat machine that works on this tunnelling site, the engine of the 938H wheel loader is equipped with a diesel particle filter and with a “Fogmaker” fire extinguishing system. In case of an emergency the operator can also manually activate the system.

Every operator has a sticker on the back of his helmet which shows that he has received the proper training from Avesco and is authorized to operate the indicated piece of machinery.

When the drill and blast operation is at full swing, the crew of the intermediate heading at Sigirino will drive the two tunnels simultaneous to the north and south. After each blast a 328D LCR tunnelling excavator moves in and clears the crown and the face from any loose rock and finishes off the tunnel profile with the hydraulic hammer. The cleared area will then be secured with rock bolts, steel meshes and shotcrete before the Sandvik underground wheel loader removes the muck at the tunnel face and side-dumps it into a mobile crushing plant. The broken material leaves the tunnel on an extendible belt conveyor system. About 20 percent of the excavated rock can be reused for onsite concrete production. The rest will be disposed for landscaping the area around the construction site.

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# THE AMS-EVENT CALENDAR

## January 2011

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<td>07 – 09 Jan</td>
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<td>08 – 14 Jan</td>
<td>23rd Colloquium of African Geology</td>
<td>Johannesburg, South Africa</td>
<td><a href="http://www.cag23.co.za">www.cag23.co.za</a></td>
</tr>
<tr>
<td>18 – 19 Jan</td>
<td>Drill &amp; Blast Europe</td>
<td>Stockholm, Sweden</td>
<td><a href="http://www.drillandblasteurope.com">www.drillandblasteurope.com</a></td>
</tr>
<tr>
<td>20 – 21 Jan</td>
<td>Colloquium — „750 years of social history in the European mining”</td>
<td>Goslar, Germany</td>
<td><a href="http://www.bergbau.tu-clausthal.de">www.bergbau.tu-clausthal.de</a></td>
</tr>
<tr>
<td>21 – 22 Jan</td>
<td>17. Drilling and Blasting Technology Colloquium 2011</td>
<td>Clausthal, Germany</td>
<td><a href="http://www.bergbau.tu-clausthal.de">www.bergbau.tu-clausthal.de</a></td>
</tr>
<tr>
<td>25 – 26 Jan</td>
<td>Regional Mining Metals and Minerals Summit – Turkey</td>
<td>Istanbul, Turkey</td>
<td><a href="http://www.eybsummits.com">www.eybsummits.com</a></td>
</tr>
<tr>
<td>26 – 27 Jan</td>
<td>TerraTec</td>
<td>Leipzig, Germany</td>
<td><a href="http://www.terratec-leipzig.de">www.terratec-leipzig.de</a></td>
</tr>
<tr>
<td>27 – 28 Jan</td>
<td>Precessing Technology Seminar 2011 – automation in the mineral and secondary raw material industry</td>
<td>Leoben, Austria</td>
<td><a href="http://www.gdmb.de">www.gdmb.de</a></td>
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</tbody>
</table>

## February 2011

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>Location</th>
<th>Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>03 – 02 Feb</td>
<td>8. Austrian geotechnology conference</td>
<td>Vienna, Austria</td>
<td><a href="http://www.vsee.at">www.vsee.at</a></td>
</tr>
<tr>
<td>06 – 09 Feb</td>
<td>37th Annual Conference on Explosives and Blasting Technique</td>
<td>San Diego, USA</td>
<td><a href="http://www.isee.org">www.isee.org</a></td>
</tr>
<tr>
<td>07 – 10 Feb</td>
<td>Mining INDBA 2011</td>
<td>Cape Town, South Africa</td>
<td><a href="http://www.miningindaba.com">www.miningindaba.com</a></td>
</tr>
<tr>
<td>08 – 09 Feb</td>
<td>Focus rock raw materials</td>
<td>Hanover, Germany</td>
<td><a href="http://www.geoplastgbh.de">www.geoplastgbh.de</a></td>
</tr>
<tr>
<td>08 – 11 Feb</td>
<td>bC India</td>
<td>Mumbai, India</td>
<td><a href="http://www.bcinia.com">www.bcinia.com</a></td>
</tr>
<tr>
<td>10 – 11 Feb</td>
<td>Coal Operations Conference “Coal 2011”</td>
<td>Wollongong, Australia</td>
<td><a href="http://www.coalconference.net.au">www.coalconference.net.au</a></td>
</tr>
<tr>
<td>10 – 12 Feb</td>
<td>Energy &amp; Environment 2011</td>
<td>New Delhi, India</td>
<td><a href="http://www.iefindia.in">www.iefindia.in</a></td>
</tr>
<tr>
<td>15 – 16 Feb</td>
<td>Unconventional Oil &amp; Gas Europe</td>
<td>Prague, Czech Republic</td>
<td><a href="http://www.unconventionaloilandgas.eu">www.unconventionaloilandgas.eu</a></td>
</tr>
<tr>
<td>16 – 18 Feb</td>
<td>Course for professional forces and executives in the mineral Raw material industry</td>
<td>Clausthal-Zellerfeld, Germany</td>
<td><a href="http://www.bergbau.tu-clausthal.de">www.bergbau.tu-clausthal.de</a></td>
</tr>
<tr>
<td>20 – 22 Feb</td>
<td>40. VDBUM Seminar</td>
<td>Braunlage, Germany</td>
<td><a href="http://www.vdbum.de">www.vdbum.de</a></td>
</tr>
<tr>
<td>22 – 24 Feb</td>
<td>Drilling Fluids and Cuttings Management Asia 2011</td>
<td>Bangkok, Thailand</td>
<td><a href="http://www.armmediaglobal.com">www.armmediaglobal.com</a></td>
</tr>
<tr>
<td>24 – 25 Feb</td>
<td>GeoTHERM – expo &amp; congress</td>
<td>Offenburg, Germany</td>
<td><a href="http://www.messe-offenburg.de">www.messe-offenburg.de</a></td>
</tr>
<tr>
<td>24 – 27 Feb</td>
<td>15. BAUMAG 2011</td>
<td>Luzern, Switzerland</td>
<td><a href="http://www.fachmessen.ch">www.fachmessen.ch</a></td>
</tr>
</tbody>
</table>
## Events

### March 2011

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>Location</th>
<th>Website</th>
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<tbody>
<tr>
<td>02 – 06 Mar 2011</td>
<td>28. Samoter</td>
<td>Verona, Italy</td>
<td><a href="http://www.samoter.com">www.samoter.com</a></td>
</tr>
<tr>
<td>03 – 04 Mar 2011</td>
<td>GeoMonitoring</td>
<td>Clausthal-Zellerfeld, Germany</td>
<td><a href="http://www.geo-monitoring.org">www.geo-monitoring.org</a></td>
</tr>
<tr>
<td>16 – 18 Mar 2011</td>
<td>INTERtunnel 2011</td>
<td>Moscow, Russia</td>
<td><a href="http://www.intertunnelrussia.com">www.intertunnelrussia.com</a></td>
</tr>
<tr>
<td>17 – 20 Mar 2011</td>
<td>Baumec 2011</td>
<td>Bozen, Italy</td>
<td><a href="http://www.fierabolzano.it/baumec/de">www.fierabolzano.it/baumec/de</a></td>
</tr>
</tbody>
</table>
STEINEXPO 2011 — LOOSENING, LOADING AND TRANSPORTING WITH POWER, SYSTEMS EXPERTISE AND SPEED!

The 8th STEINEXPO, the international demonstration exhibition for the raw materials and building materials industry, will without question rise to the occasion as a unique performance show of highly modern and powerful construction machinery technology. All the top brands in the industry will roll out next year on EM tyres or Caterpillar tracks to the great competition. When the STEINEXPO 2011 calls: Showtime!, the specialists will show their particular strengths in realistic demonstrations. But before that happens, a fair bit of planning still has to be done.
Without it, nothing takes place in raw material plants and building materials companies. Excavators, wheel loader, dump trucks, heavy vehicles, special trucks with extra-strong superstructures: all of these construction machinery and specialist transporters can be seen daily and by the dozen on construction sites. Amazing how different and how much more powerful they appear against the impressive backdrop of a quarry, and even more so in front of a quarry wall. In fact, in this setting they not only appear different, they mostly are. The manufacturers equip these special models for demanding applications in raw materials plants with adaptations that distinguish them even from same size “normal” construction site machinery. For this reason and also because of the vibrant, live operating atmosphere so similar to the daily production in the quarry, the deployment of the machinery within the context of the steinexpo is so popular.

In individual discussions with manufacturers this summer it became clear how intense the preparations for steinexpo 2011 already were, and this was confirmed again during a site visit in Nieder-Ofleiden at the end of September 2010. Exhibitors from the processing machinery sector met here with the planners of the trade fair and exhibition organisers Geoplan GmbH to have their ideas of the live presentation incorporated as a fixed component of the conceptual process. None of the major suppliers want to miss this spectacular and impressive opportunity to present their innovative strength. Confirmed registrations by Zeppelin Baumaschinen GmbH for the Caterpillar brand, and Volvo CE, Komatsu, Liebherr, Bell, Doosan, and Kiesel for the current Hitachi machines were already received at an early stage. JCB and Langendorf have also booked exhibition space.

Partnership in all areas is very important

As in 2008, at the next steinexpo some interesting combinations at the demonstrations will again be on the cards, such as the leading brands in the preparation and the construction equipment applications sector being next to each other and partly together. How should a crusher or a screen operate without the necessary aid in the form of the transportation and feeding of the material anyway?
In addition, at steinexpo 2011, proven concepts will be supported by new presentations that will add to the value of the information. For example, the large-size equipment demonstrations will not only be on view, but also brought to life throughout by professional presentations.

The prospect of demonstrations of genuinely new innovations is something else to look forward to. Liebherr will show its dump truck in action, Doosan will for the first time underscore its system expertise here with large excavators, wheel loaders and Moxy dumpers. All in all, the announcements of the exhibitors have already dramatically fuelled the curiosity and interest in the most vibrant live event of the industry next year. But now the real work is starting. For the participants the onsite meeting was the gong, so to speak, which set the complex and sophisticated detail planning in motion.

It's clear that in such a meeting the conceptual partner organisations such as the Association of German Machinery and Plant Manufacturing (VDMA), represented by the Managing Director of the Association for Building and Building Material Machines, Joachim Schmid, may not be absent. The VDMA has, like the European Aggregates Association (UEPG), the German Federal Association of Mineral Resources, the German Aggregates Federation (MIRO), and the Association of Construction Engineers and Masters, and the German Association for Construction Industry Engineers and Professionals (VDBUM), convincingly taken over the conceptual trusteeship of the fair in 2011.

It is quite clear that the backing the quarry demonstration exhibition is already receiving from partners and exhibitors will also be reflected in the media coverage. For the first time, in addition to the familiar titles of the raw and building material industry, the “stock publication” of all companies in the construction sector, the Allgemeine Bauzeitung-ABZ, will be a new media partner of steinexpo 2011.

**steinexpo**

As the biggest and most significant stone quarry demonstration exhibition on the European continent, the steinexpo had its premiere in the Niederofleiden stone quarry in September 1990. The trade fair is held in a three-year cycle. By means of impressive live demonstrations against the backdrop of a magnificent stone quarry, manufacturers and dealers of building and processing machinery, utility vehicles and heavy vehicles as well as plants for reclamation and treatment of materials put their service performance on display. The recycling of mineral building materials represents another focus point. The steinexpo is organised by Geoplan GMBH, Iffezheim.
Zeitplan und Fristen

Abgabe der Kurzfassungen der Vorträge: 1. August 2010

Bekanntgabe der Vortragsthemen: 1. September 2010

Abgabe der Druckversion zur Veröffentlichung des Vortrages: 1. November 2010


Veranstalter und Kontakt

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Dipl.-Wirtsch.-Ing. Heiner Berger
Abteilung für Maschinelle Betriebsmittel und Verfahren im Bergbau unter Tage
Telefon: (0 53 23) 72-31 79

Veranstaltungsort

Aula der Technischen Universität Clausthal
Aulastraße 1
D-38678 Clausthal-Zellerfeld

Profil


Seit 1976 kommen traditionell alle zwei Jahre Experten aus dem nationalen und internationalen Bergbau aber auch verwandten Branchen in Clausthal zusammen, um Erfahrungen, Erkenntnisse und Entwicklungen zum neuesten Stand der Technik im Bohr- und Sprengwesen auszutauschen und zu diskutieren.


In den vergangenen Jahren konnten wir durchschnittlich 300 Fachbesucher in Clausthal anlässlich unseres Kolloquiums und der begleitenden Fachausstellung begrüßen.

Vortragssammlung

Unsere 35-jährigen Tradition folgend, möchten wir den Teilnehmern auch dieses Mal hochkarätige Vorträge sowohl aus Wissenschaft und Forschung, vor allem aber aus der betrieblichen Praxis bieten.

Wir wollen Sie daher auffordern, selbst aktiv mit einem Vortrag an der Veranstaltung teilzunehmen. Interessant sind vor allem Vortragsthemen, die die Anwendung der Bohr- und Sprengtechnik in den verschiedensten Einsatzgebieten aus Anwendersicht vorstellen und besondere Herausforderungen oder die Anwendung neuer Technologien schildern.

Das Papier sollte rund 1 Seite, aber höchstens 8 Seiten umfassen. Eine kurze Zusammenfassung am Beginn des Beitrags wäre hilfreich, ebenso Tabellen, Grafiken und Bilder. Zusätzlich sollten Angaben zur Person des Vortragenden, idealerweise ein kurzer Lebenslauf sowie die Kontaktdaten ergänzt werden.

Alle akzeptierten und präsentierten Beiträge der Konferenz werden in einem Tagungsband und im Magazin AMS ONLINE Advanced Mining Solutions veröffentlicht.


Sonstiges

Im Rahmen des Kolloquiums wird ebenfalls eine Fachausstellung stattfinden. Hierzu stehen Ausstellungsflächen für 80 €/m² zur Verfügung.

Alle Beiträge des Kolloquiums werden in einem Tagungsband sowie in dem Magazin AMS ONLINE Advanced Mining Solutions veröffentlicht.

Tagungsbühr

• Teilnehmer 250,-€ (zzgl. 19% MwSt.)
• Bergbehörden 100,-€ (zzgl. 19% MwSt.)
• Studenten 20,-€ (zzgl. 19% MwSt.)

Die Tagungsbühr beinhaltet:

• Tagungsmaterial
• Pausengetränke
• Mittagsimbiss an beiden Tagen
• Teilnahme am Bergmännischen Abend auf dem Haus des Corps Montania (21.1.2011).

Zimmerreservierung

Bitte wenden Sie sich für Zimmerreservierungen direkt unter dem Stichwort „BUS 2011“ an:

Hotel Goldene Krone (0 53 23) 93 00
Harzhotel zum Prinzen (0 53 23) 9 66 10
Landhaus Kemper (0 53 23) 17 74
Pension am Hexenturm (0 53 23) 13 30

Oder an die Tourist Information:

Telefon: (0 53 23) 8 10 24
Email: info@harztourismus.de
Internet: www.oberharz.de
Lehrgang für Fach- und Führungskräfte in der mineralischen Rohstoffindustrie
16. - 18.02.2011

Planung und Projektierung
- Einführung in die Tagebautechnik
- Lagerstättenfassung und -bewertung
- Rechtliche Rahmenbedingungen der Rohstoffgewinnung im Tagebau
- Tagebauprojektierung
- Tagebauzuschnitt und Abbauplanung
- Hauptprozesse der Rohstoffgewinnung im Tagebau

Betriebsmittel und Prozesse der Rohstoffgewinnung
- Auswahl und Dimensionierung von Tagebaugeräten
- Lösen, Laden, Transportieren
- Betriebsmittel im Lockergestein (Sand und Kies, Braunkohle, Ton)
- Betriebsmittel im Festgestein (Naturstein und Kalkstein)
- Betriebsmittel in der Nassgewinnung

Rohstoffaufbereitung
- Aufbereitung und Veredlung von Steine- und Erden
- Analyse
- Zerkleinern, Klassieren, Sortieren
- Entwässern, Trocknen

Dozenten
Univ. Prof. Dr.-Ing. habil. H. Tudeshki
Dr.-Ing. K. Freytag
Dr.-Ing. V. Vogt
Dipl.-Ing. T. Hardebusch

Teilnahmebedingungen
Der Tagungsbeitrag von Euro 1300,- (zzgl. ges. MwSt.) beinhaltet die Teilnahme an der Lehrveranstaltung.

Der Selbstkostenbeitrag für Getränke, Mittagessen und eine Exkursion mit Abendveranstaltung beträgt Euro 150,- (zzgl. ges. MwSt.).

Veranstalter und Organisator
Lehrstuhl für Tagebau und Internationaler Bergbau
Institut für Bergbau, TU Clausthal
Erzstraße 20
38678 Clausthal-Zellerfeld
Telefon: +49 (0) 53 23 / 72 22 25
Telefax: +49 (0) 53 23 / 72 23 71
http://www.bergbau.tu-clausthal.de
TEILNAHMEGEBIETE
Reisedatierter Teilnahmenbeitrag
bei Anmeldung vor dem 31. Januar 2011 156 €
Regulärer Teilnahmenbeitrag: 186 €


Bitte benutzen Sie das Anmeldeformular im Internet unter: http://www.geo-monitoring.org/anmeldung.php

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TU Clausthal
Institut für Geotechnik und Martschindustrie
Embrachstr. 18
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Eine detaillierte Veranstaltungsübersicht finden Sie unter: http://www.geo-monitoring.org/suato.htm


VERANSTALTER
Univ.-Prof. Dr. Ing. Wolfgang Busch
Institut für Geotechnik und Martschindustrie, TU Clausthal

Univ.-Prof. Dr. Ing. habil. Wolfgang Weimer
Institut für Geowissenschaften und Photogrammetrie, TU Braunschweig

Univ.-Prof. Dr. Ing. Uwe Sorg
Institut für Photogrammetrie und Geoinformation, Leibniz Universität Hannover

TAGSANGEBOT „GEDOMONITORING“


Die interdisziplinär ausgerichtete tagung „GeoMonitoring“ stellt Messmethoden aus Geologie, Geotechnik und Geophyik sowie aus benachbarten Wissenschaften vor. Zur Integration ihrer Ergebnisse und zur Beschreibung des komplexen Verhaltens von Geosystemen werden für die Praxis relevante und anwendbare Modellie-

DOKTERNAT, 3. MÄRZ

11:00 Begrüßung und Eröffnung
Prof. Dr. W. Busch, Institut für Geotechnik und Martschindustrie, TU Clausthal

11:15 Vertrouen zur Technik durch Geoconsens
Prof. Dr. U. K. Kutter, Geologisches Institut Hannover

11:30 Monitoring von Länderschichten
Prof. Dr. W. Weimer, Institut für Geowissenschaften und Photogrammetrie, TU Braunschweig

11:45 Monitoring großräumiger Bodenbewegungen
Prof. Dr. W. Busch, Institut für Geotechnik und Martschindustrie, TU Clausthal

12:00 Pause

SATELLITENANGEBOT: RADARINTERFEROMETRIE

15:00 Bodenbewegungen gemessen mit satellitengestützter Radarinterferometrie - Prinzip der Messmethode aus geodätischer Sicht
Prof. Dr. U. K. Kutter, Geologisches Institut Hannover; Prof. Dr. U. Schneider, Institut für Photogrammetrie und Geoinformation Hannover

16:00 Verwendung der satellitengestützten Radaranalyse im Ingenieurwesen
Prof. Dr. J. L. Vonderhart, Technische Universität Braunschweig

16:15 Erkennung von Gebäudeschrägen
Prof. Dr. W. Busch, Institut für Geotechnik und Martschindustrie, TU Clausthal

16:30 Pause

MODELLIERUNG UND SENSORDATEN

17:00 Kombinierte Modellierung und Analyse heterogener geodätischer Daten
Prof. Dr. K. Kutter, Geologisches Institut Hannover

17:15 Modellierung und numerische Simulation der Hangstabilität
Prof. Dr. K. Kutter, Geologisches Institut Hannover

Ende 19:00 Uhr

TU Clausthal
Institut für Geotechnik und Martschindustrie
Embrachstr. 18
38678 Clausthal-Zellerfeld

17:35 Geosensorik und Geoconsens als Komponente des Geomonitorings
Prof. Dr. G. Kannberg, Institut für Geographie und Geowissenschaften, Technische Universität Braunschweig

17:50 Inseren Referent - Werkzeug auch für die Interdisziplinäre Punktwerken
Prof. Dr. G. Kannberg, Institut für Geographie und Geowissenschaften, Technische Universität Braunschweig

19:00 Abendveranstaltung (Stand Auf Saal)

FREITAG, 4. MÄRZ

GROUND BASED RADAR

9:00 Ground based synthetic aperture radar interference monitoring: Introduction
Prof. Dr. M. B. Bieniek, Institut für Geodäsie und Geoinformationstechnik, Technische Universität Braunschweig

9:45 Einsatz von GSSAR zur Erfassung des Bewegungsverhaltens von Bauwerken im Dachstuhlgebäude
Prof. Dr. M. B. Bieniek, Institut für Geodäsie und Geoinformationstechnik, Technische Universität Braunschweig

10:05 Terrestrischer Radar-camer - (100) - Ein neuerer Strategie für die Lichtenbergüberwachung
Prof. Dr. H. K. H. Schwenk, Institut für Geodäsie und Geoinformationstechnik, Technische Universität Braunschweig

10:30 Pause

HANG UND BÖHLENMONITORING

11:00 Automatisiertes Geo-Monitoring in der Ingenieur-geologie
Prof. Dr. G. Kannberg, Institut für Geodäsie und Geophysik, TU Münster, Düsseldorf

14:00 Überwachung von tagebaurelevanzen am Beispiel des Tagebaus Nordwest
Prof. Dr. W. Busch, Institut für Geotechnik und Martschindustrie, TU Clausthal

14:30 Pause

15:00 Einblicke in die individualisierte Modellierung und Analyse heterogener geodätischer Daten
Prof. Dr. K. Kutter, Geologisches Institut Hannover

16:30 Raum

EUROPEAN LANDSAT CONGRESS

17.5. - 21.5.2011

TU Clausthal
Institut für Geotechnik und Martschindustrie
Embrachstr. 18
38678 Clausthal-Zellerfeld

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www.advanced-mining.com
Fachtagung

Fokus Gesteinsrohstoffe
Kies, Sand, Naturstein

08./09. Februar 2011, Altes Rathaus, Hannover

PROGRAMM

Dienstag, 8. Februar 2011

11.30 Uhr
Registrierung der Teilnehmer

12.00 Uhr
Begrüßungsmittwoch in der Fachausstellung

12.45 Uhr
Begrüßung und Eröffnung
Michael Schultz; Präsident des BKS
Franz-Bernd Küster; Vorsitzender vero

13.15 Uhr
Qualität von Gesteinsbaustoffen:
Raus aus der technischen Defensive!
• Petrographie – Grundstein für das eigene Produktverständnis
  Dr. Albrecht Germann; Rock and Mineral Consulting, Herzogenrath
• „Fit for use“? – Richtige Auswahl von Gesteinskörnungen oder: das Dilemma der Anforderungsspirale
  Prof. Dr. Rudolf Hoscheid; Institut für Baustoffprüfung, Köln
• Brunnenbau mit Kies und Sand: schon bald ein Auslaufmodell?
  Holger Vespermann; Euroquarz, Dorsten
Moderation: Eckhard Henke; Kieswerk Müller, Lügde-Rischenau

14.30 Uhr
Kaffeepause in der Fachausstellung

15.00 Uhr
Rohstoffgewinnung und Betriebe in der Öffentlichkeit
• Vom Kieseuro zur Rohstoffabgabe – politisch motiviert und fiskalisch willkommen?
  Raimo Benger; vero/BKS, Duisburg
• Wachstum oder Stillstand – ist Bauen out?
  Christian Engelke; Bundesverband Baustoffe-Steine und Erden, Berlin
• Rohstoffbewusstsein schaffen – durch Öffentlichkeitsarbeit der Verbände
  Britta Franzheim; Quarzwerke, Frechen
  Bernhard Lemkamp; Niederrheinische Dienstleistungsgesellschaft für Kies und Sand, Duisburg
Moderation: Hans-Peter Braus; vero/BKS, Duisburg

16.15 Uhr
Kaffeepause in der Fachausstellung

16.45 Uhr
Rohstoff sicherung, Umwelt und Gesundheitsschutz
• Neuer Entwurf zu § 12a BBoSchV – Auswirkungen auf Gewinnungsbetriebe
  Reinhard Fischer; vero/BKS, Duisburg
• Brennpunkt Quarzfeinstaub: NePSi, CLP & Co.
  Walter Nelles; BV MIRO, Köln
• Rohstoff sicherung mit Hilfe der Regionalplanung
  Dr. Stephanie Gilhuber; Dr. Hermann Mader, Fachabteilung Sand- und Kiesindustrie im BIV, München
Moderation: Raimo Benger; vero/BKS, Duisburg

18.00 Uhr
Ende 1. Tag

PROGRAMM

Mittwoch, 9. Februar 2011

8.55 Uhr
Begrüßung und Eröffnung
Markus Schumacher; vero/BKS, Duisburg

9.00 Uhr
Technik und Betrieb
• Mannlose Baggerung mit automatischer Schutenbeladung
  Olmar Bauer; Rohr Bagger, Mannheim
• Trommelmotoren in der Bandfördertechnik
  Marcel Elsner; Van der Graaf Antriebstechnik, Rheine
• Der Countdown läuft – Die EuP-Richtlinie bringt Betreiberpflichten
  Michael Herbst; SEW-EURODRIVE, Graben-Neudorf
Moderation: Hans Karpowitz; Rheinische Baustoffwerke, Bergheim

10.15 Uhr
Kaffeepause in der Fachausstellung

10.45 Uhr
Pit am Arbeitsplatz – von der Aufbereitung bis zur Zentrale
Ein aktiverender Beitrag von Michael of Kunhardt; Diez

11.30 Uhr
Kaffeepause in der Fachausstellung

12.00 Uhr
Forschung und Innovation für die Praxis
• Quergedacht – neue Wege zur Entwicklung von Verfahren und Maschinen für die Rohstoffindustrie
  Sandra Weyrauch; Haver Engineering, An-Institut der TU BA Freiberg, Meissen
• Zukunft ist heute – satellitengestützte Erfassung und Diagnose von mobilen Geräten
  Thomas Schröter; Schüler Baumaschinen, Ermelo
• Innovativ und nachhaltig – Mineralschlamm in der Baukeramik
  Dr. Lutz Kraakow; ClayServer, Osterbappeln-Venne
Moderation: Markus Schumacher; vero/BKS, Duisburg

13.15 Uhr
Zusammenfassung und Schlusswort
Michael Schultz; Präsident des BKS
Franz-Bernd Küster; Vorsitzender vero

13.30 Uhr
Veranstaltungsende und Abschlussimbiß in der Fachausstellung
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