Loesche’s innovative technologies for PCI in the steel industry

Coal grinding is today an integral part of modern ironmaking plants. Loesche has been at the forefront of grinding machine design and processing for many decades, ensuring flexible, high capacity, safe operations in a variety of applications.

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Loesche has been involved in the grinding of coal since its inception in 1927. The first spring-loaded vertical mills came into use in Klingenberg, Berlin, in what was then Europe’s largest coal-fired power station. The company has continued to set the trend when it comes to substituting conventional grinding methods in many industries with highly efficient mills. This includes the grinding of raw materials for cement manufacture from the 1930s, grinding of cement and granulated blast furnace slag from the 1990s, and in the ore industry also from the 1990s. The grinding of a wide range of natural and artificial minerals has occupied an important position in the application of Loesche mills right from the start, the main areas for application being:

- The iron and steel industry
- The cement industry
- The power industry
- Plants for coal gasification for the production of a synthesis gas
- Pulverised coal production for use in other thermal processes

The increase in the throughput of the grinding mills is directly connected to the growth of the respective industrial plants. Figure 1 shows the current range of Loesche mills for coal grinding.

The number of grinding rollers is highly relevant to the throughput rate. All types of coal can be ground with Loesche mills – from petroleum coke to hard coal and brown coal.

MILL FUNCTION

The grinding material is comminuted between the rotating grinding table and the fixed grinding rollers. The axes of the conical rollers are arranged at an angle of 15° relative to the level of the grinding table, making optimum grinding as well as economic efficiency possible through the combined compressive and shearing loads (see Figure 2).

The material can be fed onto the rotating grinding table from the side or centrally from the top where it is crushed by the rollers and ground through the action of the forces generated by the hydro-pneumatic roller spring assembly. The grinding material is forced outwards by the centrifugal force of the rotating grinding table. An upwardly directed hot process gas stream captures the material in the vicinity of the louvre ring that surrounds the grinding table and conveys it to the classifier. Coarse material is rejected by the classifier (according to the grit size) and falls onto the grinding table again in the internal grit recirculation.
system for renewed grinding. The final grinding product passes through the classifier and exits the mill with the process gas flow. Figure 3 shows a 4-roller coal mill.

Typical features of Loesche coal mills are:

- Stop buffers prevent metallic contact between grinding parts, stopping spark generation (see Figures 4 and 5)
- Pressure shock resistance up to 3.5 bar (absolute), special versions up to 8 bar (absolute) upon request
- Individual guidance of grinding rollers
- Modular structure of the roller system, for use of common parts in different mill sizes
- Configuration of 2, 3, 4 or 6 grinding rollers on the grinding table (depending on throughput)
- Hydraulic swinging-out system for easier and quicker exchange of grinding parts
- Hydro-pneumatic spring system
- Control of grinding table speed is possible
- Grinding pressure control for extending the control range of the mill from 20% to 100%

Over the past few decades mills have been regularly adapted to ever-changing industrial requirements to improve the quality of the pulverised coal, in the use of different solid carbon carriers, and in their characteristics. Modern grinding plants can comminute coals with differing grindabilities, moisture contents and of different compositions with a reproducible grain size distribution of the finished product that prevents down steam processes from being negatively affected.
The variability of the grinding system is of the utmost importance for meeting the various requirements of different areas of application, especially those in the iron and steel industry for pulverised coal injection (PCI) plants, the cement industry for rotary kiln burners, coal conversion plants for coal gasification, for power stations or for pulverised coal production for a variety of thermal processes.

Loesche has always met these challenges such that today there are 6-roller mills available with a throughput of more than 300t/h to meet the high capacity demand of coal gasification plants, which in turn leads to significant savings in investment costs.

In 1986 the world's first self-inert coal grinding plant was supplied, installed and commissioned in the Dillingen iron works, Germany. This plant for the partial substitution of BF coke in with injected pulverised coal was the beginning of a new technology in BF operations. PCI technology today is state-of-the-art and an important milestone in the design of energy-efficient and economic processes in the smelting of iron ore. Figure 6 shows a typical PCI plant layout.

**SAFETY**

Safe operation is the key in coal grinding plants, as the following conditions can lead to self-ignition, deflagration or explosions:
- O₂ content (≥ 12%) in the process gas
- Ignition sources being present
- High content of volatile matter in the coal
- Increased CO content in the process gas

As a result, there is a great need for effective safety measures. These include:
- Inert operating status with a maximum O₂ content of 10% in the moist process gas of the grinding plant
- Pressure-shock resistant design
- Adequate pressure-relieving surfaces (as required)
- O₂ monitoring
- CO monitoring (also for detecting smouldering fires during standstill)
- Quick-closing gates to isolate plant components
- Avoidance of ignition sources (mechanical stop buffer)
- Safety-related design in accordance with local regulations

Figure 7 illustrates a typical plant layout.

**GRINDING PLANT INNOVATIONS**

The efforts for technical improvements of the grinding and drying process are not only related to the mill, but also to the entire grinding plant. Important peripheral components have been examined closely up to and including process modifications.

**Hot gas generation** The dry grinding process requires thermal energy for drying the moist raw material. A number of energy sources are available in the area of the blast...
furnace, including hot stove waste gas (Cowper gas), BF gas and coke oven (CO) gas. Today in most coal grinding plants for PCI, hot-gas generators predominantly use BF or CO gas as energy sources, since O₂ and CO gas peaks can occur with the use of Cowper gas, which can only be handled with increased process-related complexity. Also, when using Cowper gas, a gas-operated hot-gas generator is necessary to compensate for the variations in heat flow.

Until 1990, low-calorific gas as an energy source for the drying process was used exclusively in hot-gas generators with refractory linings, which are characterised by:

- High weight
- Delayed reaction to required adjustment of temperature in the process
- Reduced control ranges
- High residual storage heat and its required removal during emergency shut-downs via emergency stacks

Loesche has focused much attention on this process stage with the intent of optimising the above-stated characteristics and, by the early 1960s, had developed and patented a steel combustion chamber without a refractory lining (known as a LOMA® heater; see Figure 8). This significantly improved the above characteristics, making Loesche the only mill manufacturer who could handle the grinding and drying process, consisting of mill and hot-gas generator as process-related unit, from one source. All conventional fuels such as light oil, heavy oil and natural gas can be efficiently combusted.

For the PCI plant in the Taranto steelworks, Italy, a burner for low-calorific blast furnace gas was developed
in connection with the Loesche steel combustion chamber that can also provide all combustion-related requirements without a refractory lining. The burner attains a turn down ratio of 1:10 (ie, a ratio from max. to min. load), which was unknown until that time. More than 50 LOMA® heaters with multiple lance burners have been installed in steel works around the world. Examples are shown in Figures 9a to 9c.

Hot gas generators for solid fuels Due to the considerable increase in the price of light oil and natural gas, customers increasingly demand that the energy sources for the generation of process heat be substituted with solid fuels. Loesche has met this challenge over the past three years with the introduction of a joint research programme with university institutes. The objective was, similar to the developments in the area of low-calorific gas combustion, to use the combustion chamber without a refractory lining as a basis for the hot-gas generator.

Excellent results were obtained with the pilot plant shown in Figure 10 having a solid fuel burner with an output of 0.4MW from a LOMA® heater. Such positive results and industry requirements for efficient hot-gas generators for solid fuels were the basis for establishing a test facility for hot gas generators in the company’s technical centre.

A new pilot plant was designed with a hot gas generator test plant for solid fuels has a LOMA® heater Type LF 7 and a burner with a heat capacity of 1MW (see figure 11), and is coupled online with a Loesche laboratory coal mill. This enables each solid fuel to be directly tested for combustion characteristics in the context of the coal composition and the required grain size distribution. The pilot plant is used to determine precisely coal dust parameters for optimising coal combustion from different sources. It enables us to fully advise customers about the utility value of their coal.

Coal grinding plants require control ranges of at least 1.7 to 1.8 (coal grinding plants for PCI approx. 1.8). Hot-gas
generators for solid fuels currently available on the market are limited to a maximum 1:5. That made it necessary to find a solution.

The one currently being developed attains control ranges of up to 1:10. Exhaustive testing in the Loesche technical centre serves for its short-term introduction onto the market since this new technology will also find acceptance for PCI application, so that the coal dust created in the grinding plant can be used directly for hot-gas generation. The blast-furnace gas would then be available in the ever-more-popular blast-furnace gas power stations for the generation of electricity.

Recycling of waste material Oil-containing mill scale is a by-product created during hot rolling of semi-finished steel products and is extremely difficult to recycle. The quantity of oil-containing mill scale produced depends on the production processes in each respective steel works, and during the last few decades large stockpiles of scale have been produced. The iron content of the drained mill scale is typically 65-70%.

Due to its close contact with the steel industry Loesche was asked for its advice on how to deal with this scale.
Trade articles published on this topic up to then showed that the majority of approaches were either too costly or too technical. During intensive discussions at Dillingen a new approach was developed and its technical feasibility confirmed within a few weeks by theoretical and practical preliminary tests. University and industry research facilities were also used.

This process is characterised by the following features:

- The oil-containing mill scale is added to the raw coal storage at a specific volume ratio
- The coal mill scale mix is conveyed to the raw coal bunker
- Optimum homogenisation of both components takes place during the grinding and drying process
- The mix is injected into the BF tuyeres via a dosing system and injection nozzles
- This preparation, ie, the joint grinding and drying of the coal and mill scale mixture, can also be retrofitted for PCI in existing coal grinding and drying plants. It does not require additional cost-intensive equipment (except for the mill scale dosing system).

A large-scale practical test on the blast furnace in Dillingen was approved approximately six months after preliminary technical clarification and carried out for a period of one week. The results were extremely positive such that a further large-scale test was arranged to confirm the results. The main focus here was that neither the coal grinding plant nor the operation of the blast furnace was to be in any way impaired during the production processes.

The results of this test prompted the Dillingen iron works to incorporate the recycling process for oil-containing mill scale into the production process, and since 2003 oil-containing mill scale and other high-quality by-products are fed to the BF cost-effectively and without any problems (see Figure 12). Due to its success and novelty the patent rights for this process have been applied for.

CONCLUSIONS

For many decades Loesche has been a reliable partner in the supply of coal grinding plants to the steel industry for PCI plants and has been continuously and innovatively active in the optimisation of the entire grinding and drying process – including the introduction of new processing stages – to provide customers with economic and ecological benefits. MS

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