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Areas in Roller Mills Subject to Wear with Special Respect to Grinding Elements and Their Regeneration

Introduction

Roller mills have gained a firm footing in many industrial branches for the size reduction of bulk materials. Roller mills are also known as bowl mills or vertical roller mills. The advantages of mills for size reduction are not only their high throughput rates but also the high quality of the final product with respect to particle size and size distribution as well as their energy demand.

Roller mills are typically used in coal fired power plants and cement works. In power plants they are used for grinding coal and in cement works for raw material size reduction as well as for grinding coal. Lately there has been a growing demand for these types of mills for finished cement grinding and the grinding of granulated blast furnace slag. In addition there are several further applications in other branches of industry that make use of the advantages offered by roller mills.

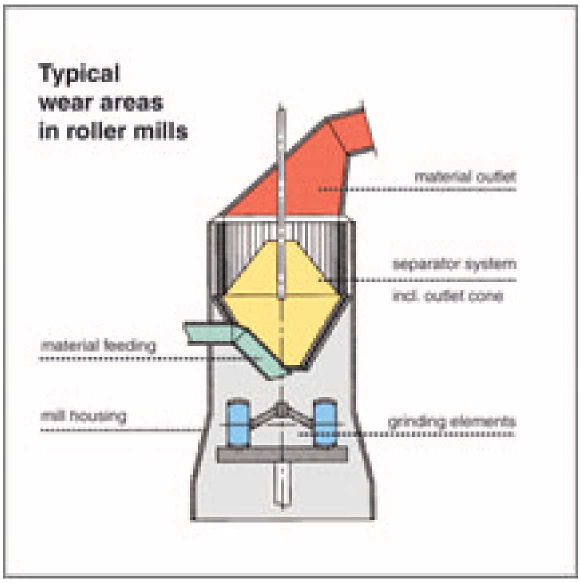

Fig. 2: Typical wear areas in roller mills

The handling and processing of bulk materials is almost always associated with significant wear (fig. 1).
In practice this means material losses of existing components and eventual failure of these components and the requirement for their replacement or repair.

Therefore, it is of vital importance to have machinery, plants and systems equipped so that they reach as long a duty cycle as possible and – in case of unavoidable wear – be able to restore their serviceability by means of appropriate measures.
All this has to be looked at from an economic view. The expenses to be incurred for safeguarding proper working condition need to be optimized.

Fig. 1: Grinding rollers in roller mills are subject to considerable wear; here worn down raw meal grinding rollers prior to regeneration

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The Wear Protection People

Areas Subject to Wear in Roller Mills

Areas in roller mills that typically are subject to wear are the material feeding section, the mill housing, the grinding elements, the integrated separating system and the product outlet (fig. 2).

■ Material Inlets

In the material inlets, solutions that utilize ABRESIST fused cast basalt as well as KALMETALL-W hard overlay welding have been successful. The fused cast basalt linings provide long duty cycles for the inlet systems due to the extreme hardness of the tiles which are normally set in KALFIX setting materials. The hard overlay welding offers the advantage of self-supporting structures combined with moderate weight.

■ Mill Housing

In the mill housing KALMETALL-C hard casting has been just as successful as KALMETALL-W hard overlay welding. In either case the tough material is characterized by good impact resistance combined with good abrasive wear resistance. Impact resistance is needed because lumpy material is flung against the outer walls during grinding.

KALMETALL-C shaped elements are mechanically fixed to the mill shell. These are frequently suspended structures that enable easy replacement after having been worn. Bolted connections or other types of fastening are feasible.

Using KALMETALL-W hard overlay welding permits the design of self-supporting structures but also can be used as replaceable wear plates. These wear plates are incorporated in the existing structure by suspended systems.

KALMETALL-HM hard metal is suggested in case of extreme wear and extreme impact stress. These are wear plates of standard steel on which extremely wear resistant hard metal tiles have been soldered-on (fig. 3). In general, the wear plates are installed as suspended structure to facilitate their exchange.

Fig. 3: Wear plates are armored with soldered-on hard metal tiles in cases of extreme wear and extreme impact

Fig. 4: Protected grinding roller yokes in a roller mill made of KALMETALL-C 153 hard casting

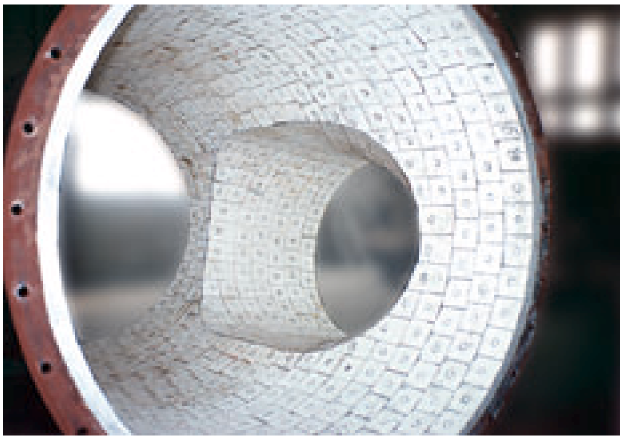

Fig. 5: KALOCER high alumina ceramics lining of a separator component with mechanically fixed standard tiles 100 x 100 mm

Recently, KALOCER high alumina ceramics have seen increased use in these mills. This solution is preferred whenever sliding wear is more predominate than impact wear. In that case the extremely hard KALOCER tiles provide long service lifetimes. The minor impact is compensated for by the fixing system which is a combination of mechanical fastening with solid backfilling by suitable KALFIX setting compounds.

■ Grinding Elements

Apart from the above applications there are numerous components in the vicinity of the grinding elements that have to be protected against wear. These include the grinding roller yokes that are reliably protected against failure by KALMETALL-C or KALMETALL-W (fig. 4).

■ Separators

A variety of materials have been successful in the zone of the integrated separators.

These are, in particular:

- ABRESIST fused cast basalt
- KALCRET hard compound
- KALOCER high alumina ceramics
- KALMETALL-W hard overlay welding

Separator housings, separator cones and separator cages require special protection. Ceramic materials are

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Fig. 6: The Kalenborn spraying technique for KALCRET-S hard compound provides reliable wear protection that is applied with short installation times

Fig. 7: Separating cones of classifiers can be efficiently protected with KALMETALL-W 100 6+4 hard overlay welding; the illustration shows a self-supporting structure of 3,000 mm diameter

suitable in the zone of the separator housing including the integrated separator cone. ABRESIST and KALOCER (fig. 5) are installed as tiles. These usually have to be mechanically fastened in roller mills because of the possible vibrations of the grinding systems.

KALCRET hard compound is a modern material for separator protection. It is wear protection „in the bag“. This wear protection material is delivered unbonded, then mixed with water and applied to a reinforcing steel system by a trowel. This material and method allow high installation rates. Sprayed-on KALCRET (fig. 6) enables even higher application rates. Large quantities of hard compound can be gunned in a very short period of time. The spraying machine will reach application rates of more than 5 m²/h based on a layer thickness of 30 mm.

KALMETAL-W hard overlay welding may be useful for separators as well. It allows self-supporting structures (fig. 7) as well as the use of wear plates. Again, the advantages include a relatively moderate weight.

The guide vanes of separator cages are also subject to strong wear. Here, thin 6 mm KALOCER high alumina ceramic tiles can provide protection. Another solution is the use of hard overlay welded plates. Self-supporting structures provided with KALSICA-A silicon carbide ceramics are a particularly long lasting alternative (fig. 8).

■ Material Outlets

ABRESIST fused cast basalt, KALCRET hard compound or KALMETALL-W hard overlay welding are preferred solutions for the mill outlet zone. The situation is similar to that at the material inlet. The use of fused cast basalt tiles or a jointless version with KALCRET hard compound has proven successful (fig. 9). Deciding in favor of KALMETALL-W can make use of self-supporting structures.

However, the grinding elements are the major wear components of a roller mill. The grinding elements include both the grinding tables and the grinding rollers.

Grinding Elements and their Regeneration

The components subject to heaviest wear in roller mills are the grinding table and grinding rollers (fig. 10). Different shapes and types exist and they vary depending on the original equipment supplier. Choices include the number of rollers, the use of single or double rollers, the use of semi circular, rectangular or trapezoidal cross sections.

Fig 8: Guide vanes of a separator in a vertical mill for coal made of KALSICA-A silicon carbide ceramics

Fig. 9: Protection for a raw meal roller mill: KALCRET installed in the outlet system, KALMETALL-W 100 used as the mill lining

Abb. 10: Grinding elements of roller mills are subject to enormous wear; this is true for both the grinding rollers and the grinding tables

Fig. 12: Grinding table segments of a 5,000 mm diameter roller mill made of KALMETALL-C; smaller diameters are cast in one piece

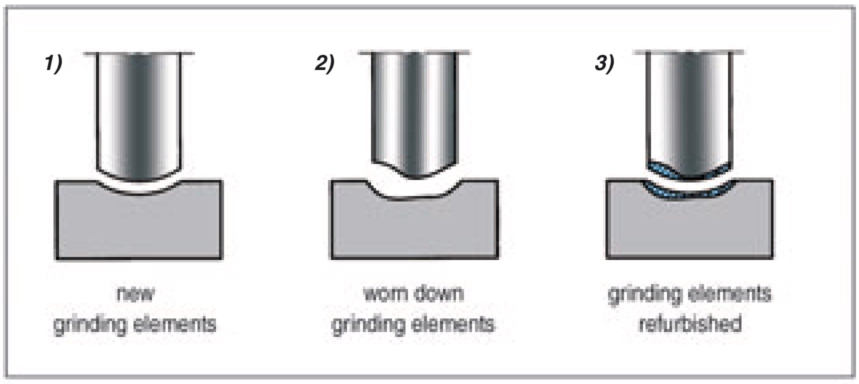

Fig. 11: The regeneration principle of grinding elements in roller mills

Fig. 13: For large diameters grinding roller outer wear sections may be of segmented type; this illustration shows a regenerated design

Grinding Tables

However, one situation is identical for all versions: a gear driven grinding table rotating under the rollers that are pressed down onto it. The raw materials are drawn in between table and rollers and reduced inside the grinding gap. This process produces considerable abrasion and impact on the surface of grinding table and rollers, which, in turn, results in an enormous amount of wear. After a given period, depending on the characteristics of the feed material, enough material has been eroded from the table and the rollers so that the grinding gap is adversely affected. The grinding properties and the grinding rate will be significantly impaired (fig. 11).

Grinding tables and rollers are mostly made of KALMETALL-C hard casting, such as quality C 153 chromium iron casting. Up to a diameter of 2,000 mm the grinding table is generally fabricated as a single piece. Larger diameters can be supplied as segments (fig. 12).

Grinding rollers can also be delivered as a single piece up to 2,000 mm diameter. Segmented solutions are used above that dimension. Another possibility are grinding rollers with outer wear sections - again either as a complete unit or of segmented design (fig. 13).

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Fig. 14: Kalenborn deliver new grinding rollers for the grinding systems for raw meal, coal and clinker; the illustration shows a KALMETALL-C 153 hard casting with a diameter of 1,500 mm

Fig. 16: Regenerated grinding roller with a rectangular cross section using KALMETALL-W 100 hard overlay welding; the diameter is 1,500 mm

What happens when unavoidable wear of the grinding elements has become so severe that grinding quality and capacity are compromised? One option is to replace the worn out components with new KALMETALL-C solutions (fig. 14).

The hardness of the material results from the formation of extremely hard chrome carbides (fig. 15).

This is a safe though relatively expensive alternative. Another choice involves the regeneration of the components with KALMETALL-W. The Kalenborn welding service can restore the original geometry and in addition, use a material that is even superior to the original casting with respect to hardness and quality (fig. 16).

Regeneration work is typically carried out in specialized shops. This allows the work to be carried out continuously under controlled and consistent conditions. But it does require that spare replacement grinding elements have to be available to avoid extended plant shutdowns.

Fig. 17 shows the typical buildup of shop welding on a grinding table. The grinding table is automatically turned to the optimal welding position by means of a rotating tilting table. The component is regenerated with the aid of flux-cored wire. The diameter of the flux-cored wire used is 2.8 mm which results in a deposit efficiency of approximately 10 kg/h.

Special self shielded flux-cored wires permit a high production quality and further reduce the processing time. The alloys used for highly wear resistant surfacing work have been specified in DIN 8555/5 and can be found in alloy group 10.

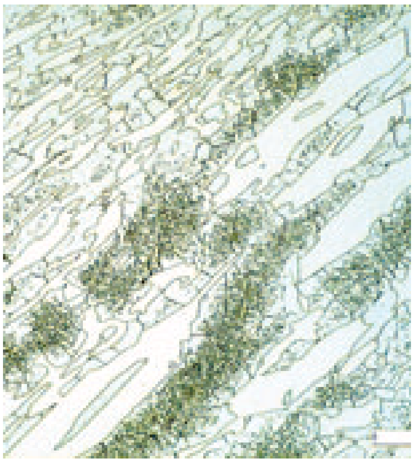

Abb. 15: The hardness of the material results from the formation of extremely hard chrome carbides

Typical Wear Protection Materials in Roller Mills

	KALOCER high alumina ceramics	KALCOR zirconium corundum	KALMETALL-HM hard metal	KALSICA silicon carbide ceramics	KALCRET hard compound	ABRESIST fused cast basalt	KALMETALL-W hard overlay welding	KALMETALL-C hard casting
Material feeding		■			■	■	■	
Mill housing	■		■				■	■
Grinding elements								
- Grinding roller yokes							■	■
- Grinding rollers							■	■
- Grinding tables							■	■
Separators								
- Separator housing	■				■	■	■	
- Separator cones	■				■	■	■	
- Separator cages	■			■	■		■	
Material outlet		■			■	■	■	

Another alternative is „in situ“ regeneration of the worn down grinding elements, i.e. while installed in the grinding mill. Hence, time consuming dismantling of the mill is not necessary and costly transport can be avoided. However, it has the drawback that the mill will still be out of operation during the welding.

Regeneration of an installed grinding table requires the table to be turned by means of an auxiliary drive. Welding proceeds automatically, with the multi wire technique used in most cases, if the component dimensions allow. Normally, two welding heads are used to reduce the extent of the plant shutdown. In most cases 2.8 mm diameter flux-cored wire is used. The alloy chosen depends on the specific application.

Surfacing of the grinding table is done continuously by means of an automatic drive until the original contour has been restored. For a coal pulverizer approximately 25 mm of new surfacing material has been added. With a diameter of 2,000 mm, this corresponds to 500 kg of newly deposited KALMETALL-W hard overlay welding. The complete process including installation and dismantling of the welding system required 84 h, i.e. 3.5 days.

The regeneration of grinding elements in roller mills is both technically and economically useful. Since KALMETALL-W hard overlay welding is markedly harder than KALMETALL-C chromium hard casting, longer, uninterrupted operating periods result while safeguarding the product quality. In actual practice, the service lives of the grinding elements can be approximately duplicated when using KALMETALL-W. Regeneration of the grinding elements is less expensive than the purchase of new castings.

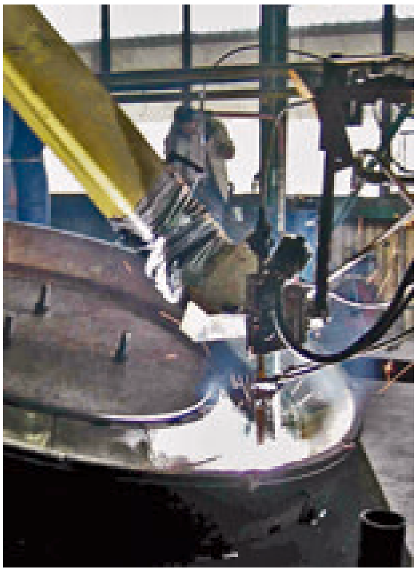

Fig. 17: Regeneration of a worn grinding table in the special Kalenborn shop

Abb.19: Knowledge gained during the regeneration of grinding elements ensure excellent quality and durability of the overlay welding; in addition, the weld pattern shown enhances the material feed between the grinding elements

Fig. 18: The Kalenborn service warrants efficient regeneration of grinding rollers with KALMETALL-W 100 hard overlay welding

■ Grinding Rollers

The statements made above about grinding tables are equally valid for grinding rollers. Fig. 18 shows one of the three outer wear sections of a cement plant raw meal grinding mill mounted on an auxiliary structure for the regeneration work. The finished grinding rollers have a diameter of 3,000 mm.

The chrome iron hard castings used for the original outer wear sections displayed 80 mm of wear after a short 9 month operating period. This required urgent remedial measures. The cement plant contacted the KALMETALL-W welding service.

With the customer's close cooperation, the grinding rollers were regenerated by hard overlay welding in a building directly adjacent to the grinding plant.

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Such regeneration work requires rotating equipment which will operate smoothly, even at low speed, despite the large weight of the components. Moreover, the welding equipment needs to operate continuously for 200 to 300 h without failure while ensuring consistent quality.

The KALMETALL-W 100 self shielded flux-cored wire was used as for the above job. The multi pass weld has a finished deposit thickness of approximately 80 mm (fig. 19). Some 1,300 kg weld material was needed to restore the original geometry of each outer wear section. The average deposit rate was 8 kg per hour.

For the project above, the grinding table has been regenerated along with the grinding rollers. The grinding table diameter is 5,200 mm. The regeneration work has been done with the components installed in the mill, proof that even extremely large components can be regenerated by welding. However, this requires certain working conditions and a competent expert team being available for the job.

Summary

Roller mills used for the reduction of bulk materials in various industries are subject to considerable wear. High grinding quality and trouble-free continuous operation make it necessary that optimal materials are used in the different mill areas. Time tested hard lining materials used to provide long operation periods include:

- ABRESIST fused cast basalt
- KALOCER high alumina ceramics
- KALCRET hard compound
- KALMETALL-W hard overlay welding
- KALMETALL-C hard casting

KALMETALL-W hard overlay welding is also suitable for the regeneration of grinding elements, saving the cost for the purchase of spare parts and also increasing the service lives of the components.

While the regeneration of grinding elements can be implemented without difficulty in experienced special coating shops, the steadily larger components and the demand for shortest possible shutdown periods mean that regeneration at the site will be requested more and more in the future. This requires suitable equipment and qualified service teams to ensure that the jobs will be successfully realized. Experience has shown that the relevant expert companies have the necessary know how.

However, wear in the basic industries is not restricted to roller mills. Other grinding systems are subject to just as heavy stress during everyday operation. The equipment concerned includes horizontal mills such as roller presses or other mills.

An exact analysis will have to be made to determine the action needed to arrive at similarly good results as for roller mills. When the correct wear protection materials and fastening systems are used, excellent results can be obtained for grinding systems in the basic industry.

Wear Resistant Lining in Practice

Lining	Material Hardness		Process Parameters						Remarks
	Mohs(1)	Vickers HV (2)	Max. conveying volocity m/sec	Material density g/cm²	Max. temperature (3) °C	°F	Thermal shock resistance	Impact wear resistance	
KALSICA-S silicon carbide ceramics	9.3	(2,300)	35	>3.0	1,000	1,832	++++	++	For extreme applications
KALOCER high alumina ceramics	9.1	(2,100)	>30	>3.0	350	662	0	+	Standard tiles, thin wall cylinders and tiles
KALCOR zirconium corundum	9	(2,000)	>30	>3.0	800	1,472	++	++	Large tiles, shaped elements, great wall thickness
KALSICA-N silicon carbide ceramics	8.8	(1,800)	>25	>3.0	1,000	1,832	+++	+	Good temperature resistance/thermal shock resistance
KALCOR-S sintered zirconium corundum	8.5	(1,600)	>25		800	1,472	+++	++	Economic KALCOR
KALCRET-B hard compound	8.1	(1,250)	22	≤3.0	800	1,472	+++	+	Supplied in bags, no joints, high temperatures
ABRESIST fused cast basalt	8	(1,140)	22	≤3.0	350	662	0	+	Flow volumes up to 3.0 g/cm³, up to 22 m/sec, limited temperatures
KALMETALL-W 100 hard overlay welding	(7.5)	700	20	-	350	662	++	++	Impact resistant, low weight
KALMETALL-C hard casting	(7.2)	580	20	-	350	662	++	+++	Impact resistant, economic in case of large quantities
KALCERAM hard ceramics	6	(500)	-	-	350	662	0	+	Bunker lining, slide promotion

(1) The Mohs scale is applicable only to ceramic materials - no more than comparison values for other materials (values given in brackets)

(2) The Vickers HV values are only valid for metallic materials - no more than comparison values for other materials (values given in brackets)

(3) The specified temperatures refer to standard applications; other temperatures must be agreed upon with the technical departments of Kalenborn

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