HEXADUR® in Cement Industry - 25 years of operation with HEXADUR® protected HPGR rollers

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Introduction

Since 1986 high-pressure grinding rolls (HPGRs) have been used in the cement industry for grinding of clinker, limestone and blast furnace slag.

Feed material is fed to the gravity feeding system from a filled hopper and then into the gap between two rollers rotating against each other. The movable (floating) roller is hydraulically pressed against the material bed and the fixed roller. Within the particle bed compressive and shear forces cause mechanical interactions of the individual drawn in particles responding with fracture or crack initiation [1,2]. Due to the high pressure, acting in the gap, the feed material is densified to an agglomerate (flake). Disagglomeration of this flake requires minimal energy because of the numerous pre-cracked particles. Using this indirect crushing operation in HPGRs results in a remarkably lower energy consumption compared to other conventional methods for comminution such as ball mills or vertical mills [3,4].

Although comminution with HPGR's keeps the contacts between feed material and roller surface to a minimum, the crushing tools wear out because of abrasion and indentation. This reduces availability, generates significant costs for regeneration or replacement of the roller, causes production losses and increases energy costs. Thus, wear surface developments target the combination of high service lifetime and low operating costs [5]. Improvements in the intake behavior as well as the surface wear protection contribute to an overall cost reduction.

Operational experiences with HPGRs show that only hard phase rich materials are able to resist tribological loads in the roller gap properly. Morphological parameters such as type, shape, size, volume fraction and distribution of the hard phases are of particular importance [6].

In this article, we will focus on the commonly available wear protection surfaces and their performance related to output and maintenance.

Welded roller surfaces (hard facing)

In many applications, solid welded rollers are in use, which have been hard-faced by welding on an iron based high wear resistant material. Welded rollers are manufactured with hard faced patterns such as chevron, diamond, zigzag, etc. The patterns help in building up a layer of the feed material on the roller surface (Autogenous Protective Layer-APL) which helps in improving the friction factor and thereby improving the output and additionally protecting the underlying hard faced layer from further wear. However, the patterns need to be regularly maintained so that feed material sticks onto the surface.

In the majority of cases, a crack-free hard facing is not possible. Initiated cracks can propagate and combine in or beneath the welded hard layer leading to large-scale spalling of the roll surface. Refurbishment of such failures requires complete removal of the hard facing, gouging off of detected cracks in the roller base material as well as rebuilding of the whole wear protection layer. This procedure generates high costs and technical risks. According to experience, any further refurbishment can cause an increase of crack depth in the base body, so that irreparable spalling cannot be excluded [7]. Nevertheless, hard faced rollers can be repaired by welding several times before they have to be scrapped. The welded roller surfaces take advantage of relatively low entry costs and could be operated at higher specific pressing force of up to 6500 kN/m², but being maintenance intensive and therefore not the optimum solution for the long run. The throughput of the machine directly depends on the patterns and fluctuates with pattern wear.

New hard faced rollers

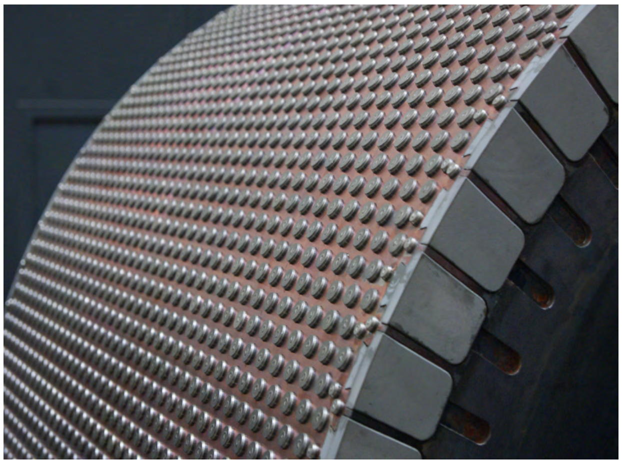
Used hard faced rollers

Studded roller surfaces

Studs or cemented carbide pins fitted into the roller surface are also being used since many years for wear protection. Due to its material composition, it has high hardness and therefore is highly wear resistant. The geometry of the location of the studs also supports feed material sticking onto the roller surface (APL) and therefore constant throughput.

Stud rollers are delivered in sleeve form so the customer has the possibility to keep on using the roller core even though the sleeve has reached its end of lifetime.

Stud wear protected surfaces are relatively costlier compared to welded surfaces and require less maintenance provided being operated only upto some lower specific forces but not to the desired range of 6500 kN/m² which is required for grinding of clinker. Operation at lower forces will compromise the output and hence higher energy costs. Operation at higher forces leads to fracture or chipping off of the hard studs. Due to these fractures, the APL is lost and hence wear of the steel base body occurs. Increasing maintenance costs have to be surely considered if operated at higher forces.

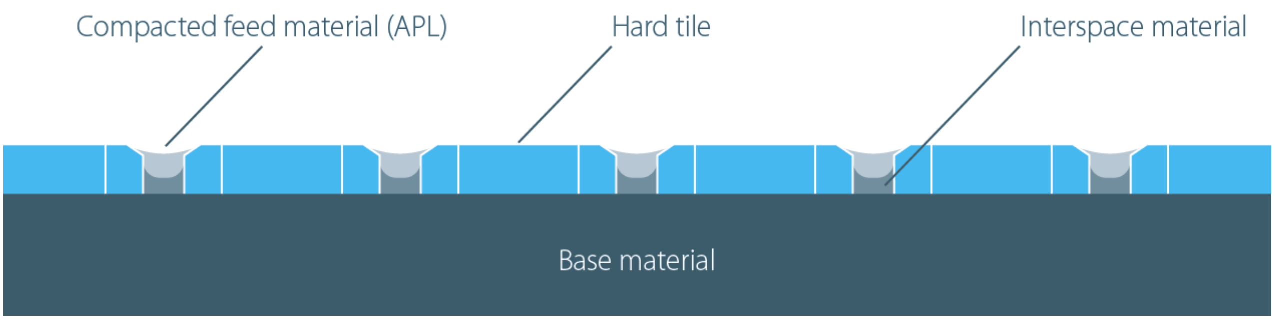


New stud Roller

Used stud Roller

The Hexadur® System – Zero Maintenance Wear Protection Technology

The Hexadur® system has been developed especially for HPGR applications with sleeve-shaft technology to adhere to the requirements in the areas of process technology (rough tool surface in order to produce high friction between the roller and feed material), feed material acting as an autogenous protection layer (APL). This comb-like profile increases the friction between the tool surface and feed material and subsequently improves intake behavior as well as throughput of the machine. Furthermore, these effects can be enforced by generating a macroscopical surface profile with hexagons having different heights.



wear resistance (high volume fraction of hard phases in the wear protection layer) and structural integrity (high strength, ductility and fracture toughness of the roll material).

The Hexadur® wear protection concept comprises an applied combination of materials with different, but well-defined required properties. Hexadur® involves coating a forged steel sleeve with a thick wear resistant layer using powder metallurgy and HIP-cladding-technique [6]. During hot isostatic pressing (HIP) (i.e. under extreme high pressure and temperature), a special structured wear resistant layer is diffusion-welded on a ductile base body of sufficient strength. The hexagonal tiles have an extremely high and application-oriented wear resistance, the interspacing between the hexagons exhibits a systematically lowered resistance to abrasive wear. These interspacings wash out after a short time in service. The arising grooves are filled up with crushed The thickness of a Hexadur® layer depends on the feed material as well as the required service lifetime and is selectable from 10 to 50 mm.

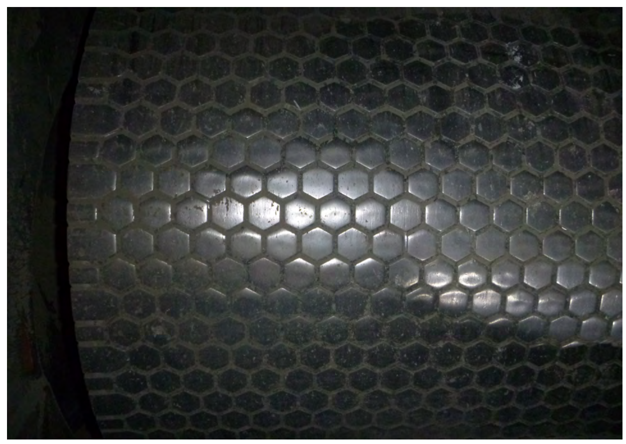
The hexagonal areas are made of wear resistant powder metallurgical hard alloys or metal matrix composite (MMC) consisting of an iron-, nickel or cobalt-based metal matrix and ceramic hard phases (e.g. tungsten carbides, titanium carbides, niobium carbides, vanadium carbides, chromium carbides, chromium borides, titanium borides or mixtures thereof). Composition and morphology of the material within these hexagons determine the wear resistance of the surface, so that high volume fractions of fine dispersed hard phases, as well as coarse hard phases of adjusted size and shape can be used. A homogenous microstructure causes the relatively high toughness of the powder metallurgically produced materials in contrast to materials produced by casting or welding. Due to the considerably decreased hard phase content, the interspacing material between the hexagons possesses a particularly high resistance against crack propagation, avoiding transmission of local damages to other hexagons and thus spallings of large-scaled surface areas. The abstracted principle of the HEXADUR® surface is given above. It is specially designed according to the demands on high wear resistance and structural integrity. Many different combinations of metal matrices and hard phases can be realized by HIP-cladding, even those configurations which cannot be produced by melt metallurgical techniques such as welding.

Experiences with HEXADUR®

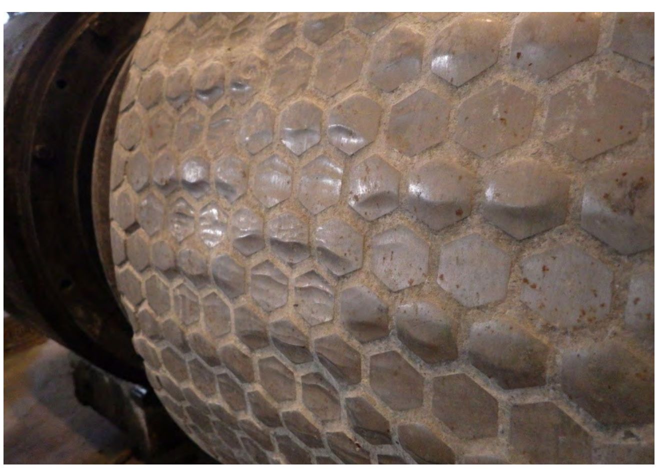
In 1996, first HEXADUR® roller was installed at a Norwegian cement plant onto a Köppern HPGR for testing under real service conditions as well as comparison with a conventional welded (hardfaced) roller [6]. The thickness of the Hexadur® layer was 10 mm. The wear protection of the counter roller consisted of a usual multilayer hard facing of type OA600 with hardness of 58 HRC and thickness of 15 mm. Whereas the hard faced roller wore out completely after 2500 service hours, only about one sixth of the Hexadur® thickness was lost. Finally, Hexadur® rollers in this application reached a lifetime of 76000 hours of operation.

Hexadur® is being used in many plants around the world and also for HPGR's from other suppliers. In all the applications, Hexadur® has shown a very low wear rate ranging from 1.5 mm to 3 mm for every 10000 hours of operation inspite of operating at higher specific force of 6500 kN/m². The profile remains unaltered throughout its lifetime and hence no loss of production was experienced.

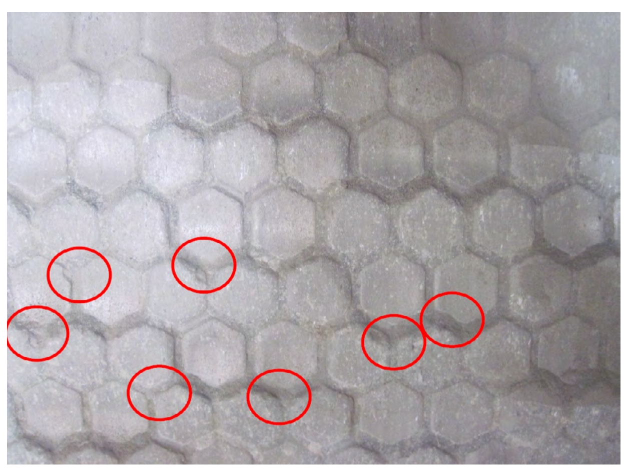
New Hexadur® Surface



Hexadur® surface after 33600 hours of operation Expected Lifetime of wear surface more than 100000 hours of operation.



Hexadur® surface after 76000 hours of operation



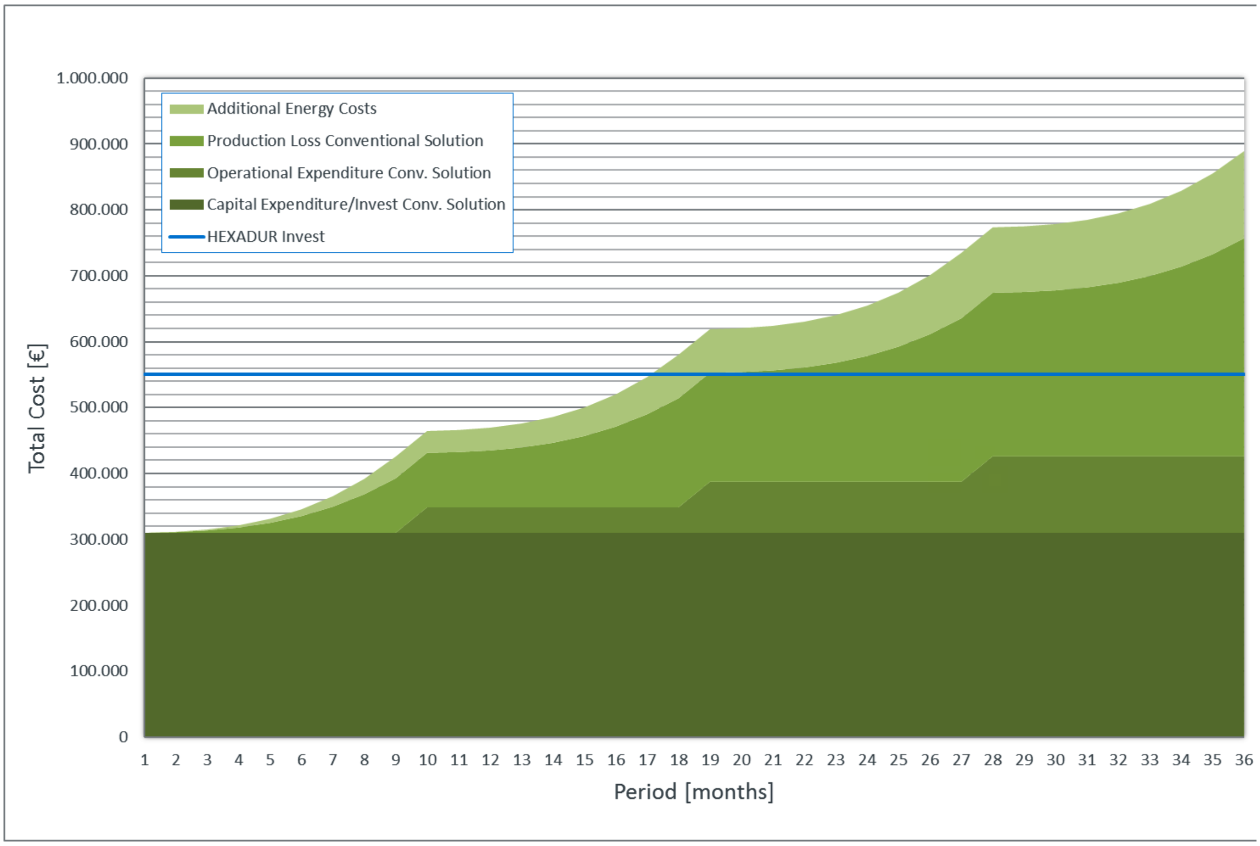
Such damages due to passage of foreign metal do not require any kind of maintenance repair as the cracks do no propagate due to multi metal compound material.

Financial aspects of Hexadur®

Operational costs of an HPGR mainly consist of energy and wear protection costs [5]. Repairing charges for maintenance and inspection of wear parts have to be considered, which may act as a counterbalance to the energy savings. If an HPGR has to be operated under reduced pressing force and throughput for reasons of prolonging the tool life time, the advantages of that comminution technology could be lost with respect to the energy costs [7,13].

For comminution of high abrasive feed material, the Hexadur® wear protection concept promises clearly increased tool lifetime and financial savings compared to the other available wear protection layers and wear resistant castings. If tramp material causes local damages, repair work becomes redundant owing to the self-regenerating potential of the surface [14]. In addition to this, intake behavior and material throughput will also be enhanced. Higher entry costs are compensated as a result of significant cost savings due to a maintenance- and trouble-free operation. The typical return of Investment (ROI) for existing customers was between 12 to 24 months of operation. Hexadur® warranty and operational life are much higher than the ROI, therefore customers have profited from the savings rather than spending on energy and maintenance cost. It has been shown in a number of further applications in Europe, North and South America, Middle East and Asia that the lifetime of HEXADUR® rollers exceeds the lifetime of welded (hardfaced) rollers up to a factor of ten [14].

Köppern supports customer by calculating the payback period based on the actual operational and maintenance costs. Above is a typical example in which the customer paid €300000 for a set of welded rollers but went on spending on those rollers for repair and refurbishment, production losses thereby energy losses. The blue line is the cost of Hexadur® rollers. The payback achieved by this customer was between 17 and 18 months of operation.



Conclusion

The HIP-cladded HEXADUR® wear protection comprises an applied combination of materials with different, but well defined properties with regard to process technology, structural integrity and wear resistance.

The interspacings between the hexagons are filled up with crushed feed material, building up a comb-like autogenous wear protection layer (APL) and improving intake behavior as well as throughput of the machine. A tough interspacing material creates high resistance against propagation of local damages to neighboring hexagons. Moreover, the hexagons are very tolerant to tramp material due to the potential for smoothing partial chippings without any consequences for the tool life.

The completely maintenance-free operation of Hexadur® rollers combined with maximum availability over a prolonged operation period has improved the total cost frame and clearly spoken for the Hexadur® wear protection system.

Addional services provided by Köppern

Since last years Köppern has provided various support/solutions to its customers in the form of mechanical and process audits of the existing grinding circuits (with or without HPGR's) to find out the bottlenecks and decrease the energy demand. After the site visit, the customer receives a report with recommendations with time limits such as short, mid and long-term goals and with financial indications on each. Köppern has also successfully supplied hydraulic and feeding systems for HPGR's of other makes and due to these modifications, the customers have benefited from production increase and lower energy demand.

For more details, please contact us at info@koeppern.de or www.koeppern-international.com

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