HEXADUR® in Cement Industry – zero maintenance wear protection surface for HPGR rollers

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Introduction

Since 1986 high-pressure grinding rolls (HPGRs) are operated in the cement industry to grind 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 a fracture or crack initiation [1,2]. Due to the high pressure acting in the gap, the feed material is densified to an agglomerate (flake). Dis-agglomeration of this flake requires minimal energy because of the numerous pre-cracked particles. This indirect crushing operation in HPGRs results in remarkably lower energy consumption than conventional comminution methods 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. Wear is aggravated when grinding abrasive material such as slag or limestone or material with free silica. This means that the roller surfaces experience high wear and needs frequent maintenances. This reduces availability, generates high 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 lifetimes and low operating costs [5]. Improvements in the intake behaviour and the surface wear protection contribute to an overall cost reduction.

Operational experiences with HPGRs show that only hard phase-rich materials can adequately resist tribological loads in the roller gap. Morphological parameters such as type, geometry, size, volume fraction, and hard phases distribution are essential [6].

This article focuses on the commonly available wear protection surfaces and their performance related to output and maintenance.

Welded roller surfaces (hard facing)

Solid welded rollers are in use in many applications, 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 build up a layer of the feed material on the roller surface (Autogenous Protective Layer-APL) which helps in improving the friction factor, improves the output, and protects the underlying hard face layer from further wear. However, the patterns need to be regularly maintained, so that feed material sticks onto the surface.

A crack-free welded surface is not possible as welding initiates cracks that propagate during operation and combine in or beneath the welded hard layer, leading to large-scale spalling of the roll surface. Refurbishing such failures requires complete removal of the hard facing, gouging off detected cracks in the roller base material, and rebuilding the whole wear protection layer. This procedure generates high costs and risks. According to experience, any further refurbishment can cause an increase of crack depths in the base body so that irreparable spalling cannot be excluded [7]. The welded surface could be repaired only at certain times, and then the roller must be scrapped.

The welded roller surfaces take advantage of relatively low entry costs and could be operated at a higher specific pressing force of up to 6500 kN/m² but being maintenance-intensive, therefore not the optimum solution for the long run. The machine's throughput depends on the patterns and fluctuates with pattern wear. (Fig1.)

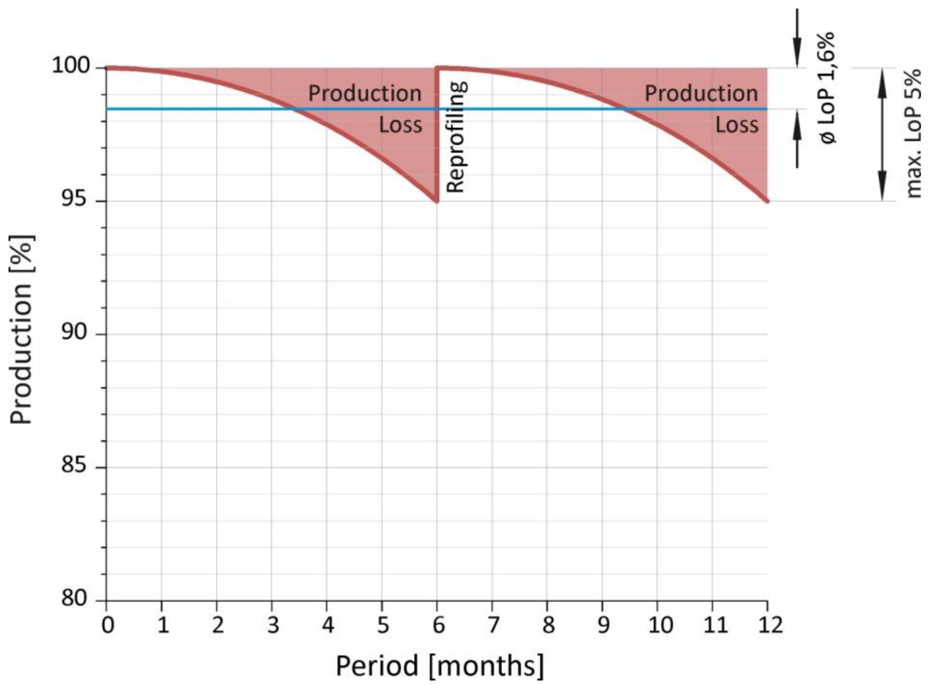
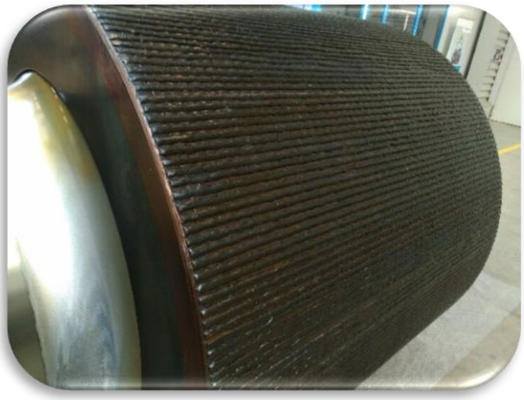


Fig.1




New hard faced rollers



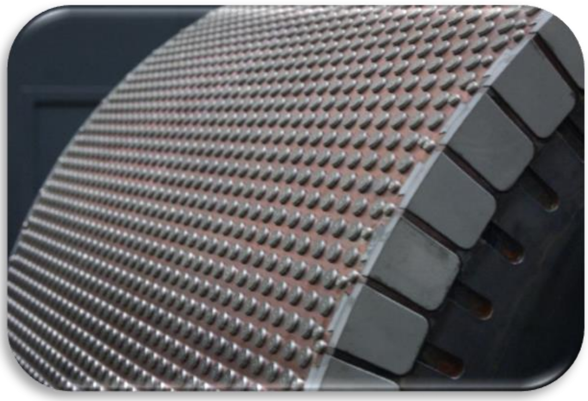
Used hard faced rollers

Stud Roller surfaces

Studs or Tungsten carbides pins fitted into the roller surface are also being used in the last years for wear protection. Due to its material composition, it has high hardness and therefore is more wear-resistant. The Roller surface is manufactured from standard steel with significantly less hardness and low wear-resistant properties. The geometry of the Stud location facilitates feed material sticking onto the roller surface (**APL**), and feed material sticking to the roller surface also enhances the friction factor.

Studs are delivered in sleeve form so the customer can use the roller core even though the sleeve has reached the end of its lifetime.

Stud wear protection surfaces are relatively costlier than welded surfaces and require less maintenance provided, being operated only up to 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 surely compromises output and hence higher energy costs. Operation at higher forces leads to breakage or chipping off the hard Studs. Due to these breakages, the APL is lost and hence wear of the usual steel base layer occurs. Increasing maintenance costs to be indeed considered if operated at higher forces.



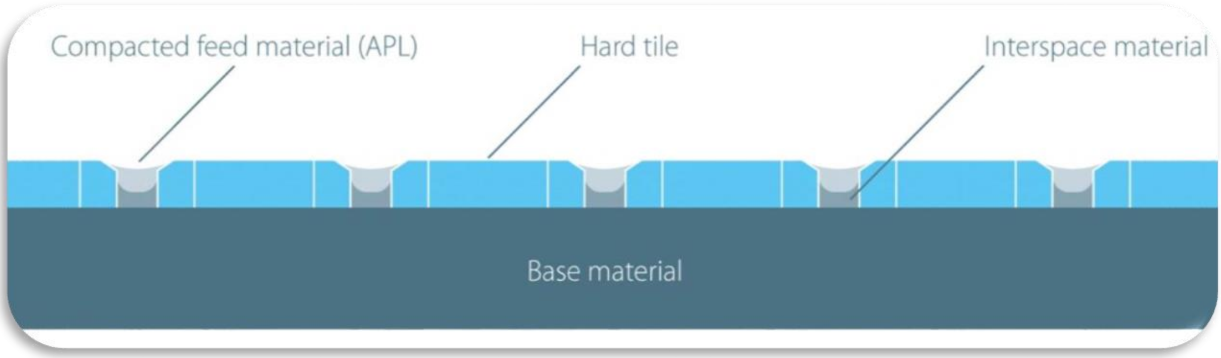
New Stud Roller

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 to produce high friction between the roller and cement clinker), 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 thick wear-resistant layer using powder metallurgy and HIP-cladding technique [6]. During hot isostatic pressing (HIP) (i.e. under extremely high pressure and temperature), a specially 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 interspacing's wash out after a short time in service. The arising grooves are filled up with crushed 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 behaviour as well as the throughput of the machine. Furthermore, these effects can be enforced by generating a macroscopical surface profile with hexagons having different heights.



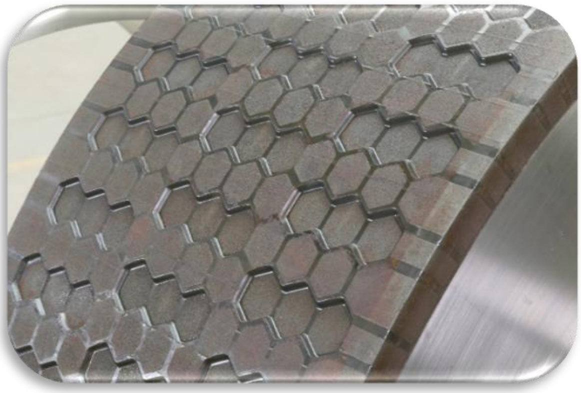
The thickness of a HEXADUR® layer depends on the feed material and the required service lifetime and is selectable from 10 to 50 mm.

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 hard ceramic phases (e.g. tungsten carbides, titanium carbides, niobium carbides, vanadium carbides, chromium carbides, chromium borides, titanium borides or mixtures thereof). 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 an exceptionally high resistance against crack propagation, avoiding transmission of local damages to other hexagons and thus spallings of large-scaled surface areas. The principle of the HEXADUR® surface is abstracted as given above, and it is specially designed according to the demands on high wear resistance and structural integrity.

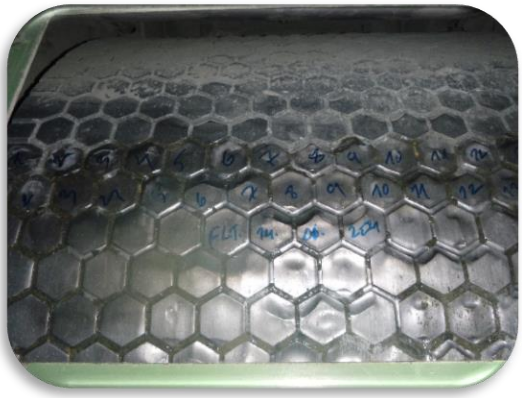
Experiences with HEXADUR®

In 1996, the first HEXADUR® roller was installed at a Norwegian cement plant onto a Köppern HPGR for testing under real service conditions compared to a conventional welded (hard faced) 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 a hardness of 58 HRC and thickness of 15 mm. The hard-faced roller wore out entirely after 2500 service hours. Only about one-sixth of the HEXADUR® thickness was lost because of the encouraging result customer replaced welded roller with HEXADUR®. The first set operated for 75000 hours.

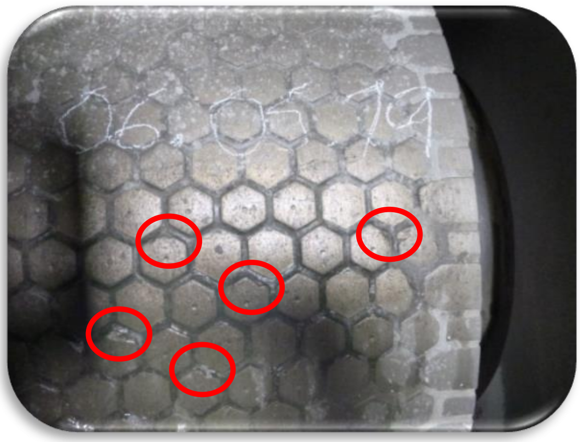
In the last years, HEXADUR® has been used in many plants worldwide and for HPGR's from other suppliers. Till now, in all our applications, HEXADUR® has shown a very low wear rate ranging from 0.5 mm to 3 mm for every 10000 operating hours, and this even despite operating at a higher specific force of 6500 kN/m². The profile remains unaltered throughout its lifetime, and hence no loss of production has been experienced.



New HEXADUR® Surface



HEXADUR® surface after 53700 hours of operation. The expected lifetime of wear surface is more than 100000 hours of operation.

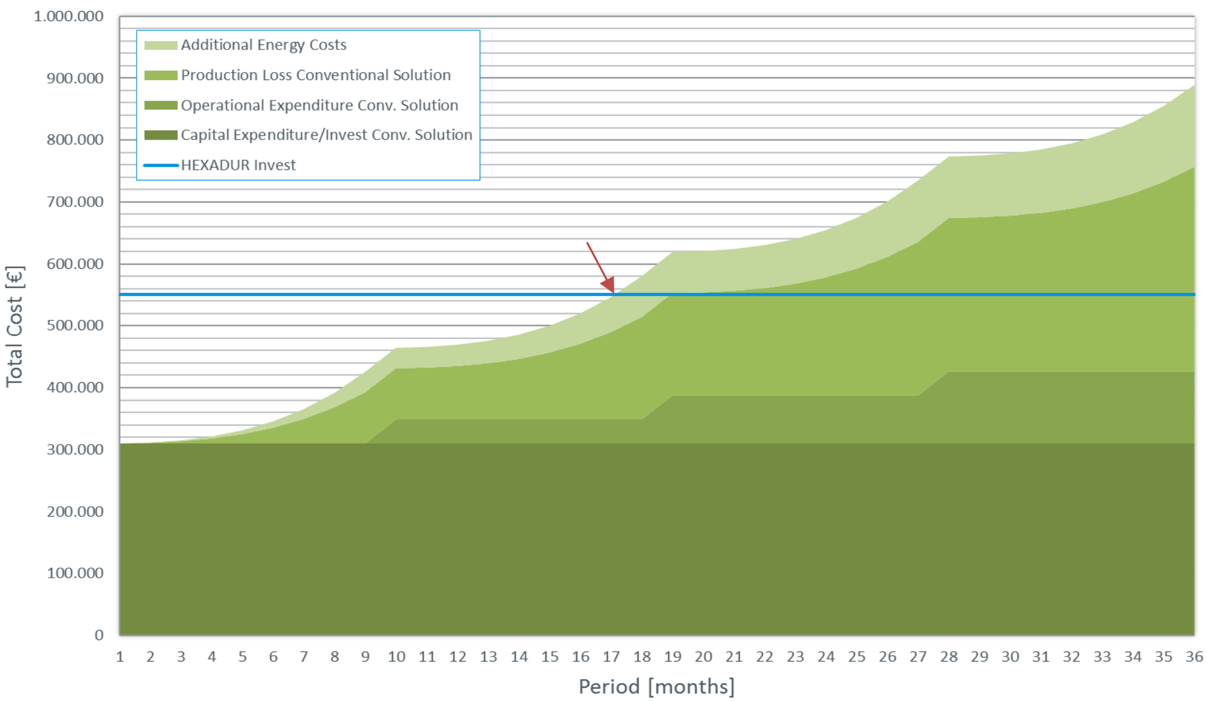


HEXADUR® surface damaged with foreign material Such damages due to the passage of foreign metal do not require maintenance as the cracks do not propagate due to multi-metal composite.

Financial aspects of HEXADUR®

The 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 counterbalance the energy savings. If an HPGR has to be operated under reduced pressing force and throughput for reasons of prolonging the tool lifetime, the advantages of that comminution technology could be lost with regards to the energy costs [7,13].

For comminuting high abrasive feed material, the HEXADUR® wear protection concept clearly increases tool life and financial savings compared to the other available wear protection layers and wear-resistant castings. Repair work becomes redundant if tramp material causes local damage due to the surface's self-regenerating potential [14]. In addition, intake behaviour and material throughput will also be enhanced. Higher entry costs are compensated for significant cost savings due to maintenance- and trouble-free operation. The typical return of Investment (ROI) for existing customers is between 12 to 24 months of operation, and the HEXADUR® warranty and operational life are much higher than the ROI. Therefore customers have profited from the savings rather than energy and maintenance costs. It has been shown in several further applications in Europe, North and South America and Asia that the lifetime of HEXADUR® rollers exceeds the lifetime of welded (hard faced) rollers up to a factor of ten [14].



Köppern supports customers by calculating the payback period based on operational and maintenance costs. Above is a typical example in which the customer paid €300,000 for a set of welded rollers but went on spending on those rollers for intermediate repairs and refurbishments. The resulting and additional effects are production losses as well as energy losses. The blue line is the cost of HEXADUR® rollers. Its payback was only 17 and 18 months for this specific customer application.

Another live experience from a customer in Asia where two identical presses of other makes are operating and feeding same material to both the presses. Back in 2013 in one of the presses HEXADUR® was installed and welded rollers from other manufacturer in the other press. The grinding plant operating with conventional welded rollers noted a significant performance loss during operation of those rolleres from 190 tph to 170 tph over a period of 18 months whereas HEXADUR® had a constant performance. Despite higher purchase price the customer finally decided to replace the welded rollers with HEXADUR®, but the experience showed that this investment was very fast recovered by a higher and constant performance. As on date, these plants are still operating with first sets of HEXADUR®.

A concluding statement from Mr Thomas Holzinger, MD of Holzinger Consulting (Process Consulting Cement & Minerals), who was meanwhile involved in several projects as an independent third party, is given below:

"Maintenance-free operation of HEXADUR® rollers combined with maximum availability and grip over a prolonged operation period, including Köppern technical support, has significantly improved the total roller cost frame. HEXADUR® wear protection system together with the unique gravity feeder and hydraulic system has Köppern made to a reliable partner in the cement and mineral industry."

For more details, don't hesitate to get in touch with us at info@koeppern.de or www.koeppern-international.com

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