The Road to No Wear

Karl Mohr, Vautid GmbH, Germany, describes the advantages of different material and design solutions to fight wear.

Introduction

Separating, mixing and burning processes cause considerable wear and tear on machine parts, often intensified by heat exposure. To counter this, an analysis of the wear system is recommended, together with corresponding design and materials-related measures. Anti-wear measures include hardfacing materials, composite wear plates, white cast iron, composite casting and heat-resistant cast parts. The advantages of individual material and design solutions are described in this article.

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Wear systems

Wear systems always consist of a base body (Figure 1 – 1), which is part of the machine design and subject to wear, a counter body (2) and the intermediate material (3), possibly fluids or lubricants. In addition, the surrounding medium, such as heat or corrosion, can promote wear. Basic anti-wear principles have established that it is not the absolute hardness of the stressed base body that is important here, but the hardness ratio between the attacking medium and the corresponding base body. The wear stress caused by materials of varying hardness is not continuous, but gradual (Figure 2).

Wear is low if the attacking material is softer than the metallic base body and the wear system is on the lower shelf. By contrast, wear is high if the attacking material is harder than the metallic base body and the wear system is on the upper shelf. Essentially, there are three starting points for reducing wear:

- Process engineering.
- Operations engineering.
- Materials engineering.

The first two options are generally subject to the particular conditions of the individual application, whereas the materials-based options have general validity. This article will discuss the latter options.

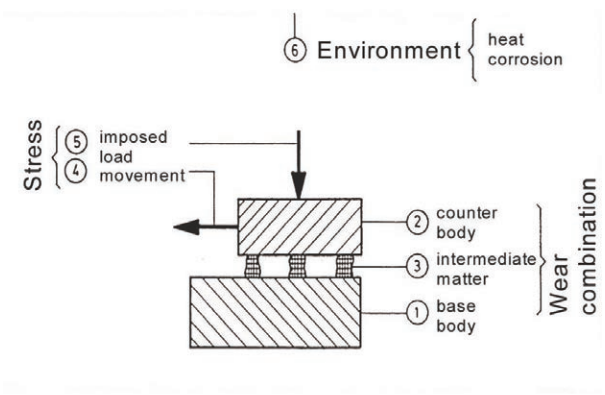

Figure 1. Wear system according to DIN 50320.

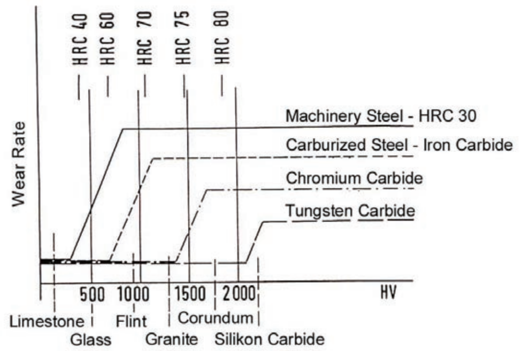

Figure 2. Definition of upper and lower shelf in wear technology.

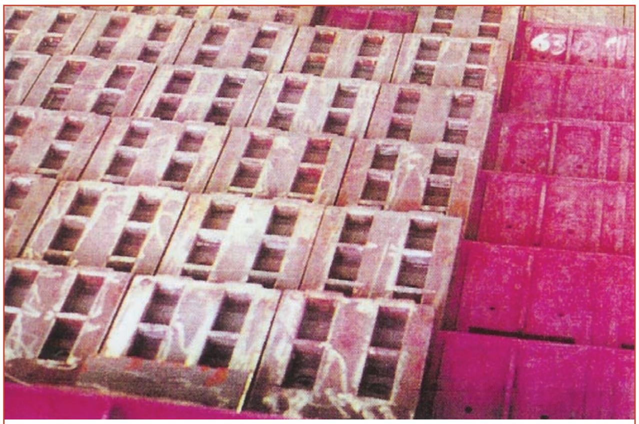

Figure 3. Cooling plates made of heat-resistant steel casting.

Applications in the high-temperature zone

The input materials for the calcination process are heated to a temperature of around 1000 °C. The linings, conveyor equipment and tools in these units must also be able to withstand such temperatures. Furthermore, these components are exposed to a permanent abrasion load during contact with the clinker. Combinations of the two types of load on the machine components may also occur in many applications, illustrated here by two examples.

Lepol grate

As is well known, a Lepol grate is used for drying and precalcining the raw meal, which is subjected to top-down heat treatment for the calcination process. The process air required for calcination is sucked down through the grate; therefore this component must be able to withstand temperature loads of up to 1000 °C. This is achieved by using heat-resistant steels, such as 1.4777, which retains its mechanical properties up to temperatures of 1100 °C without scaling.

Cast parts for the clinker cooler

Cooling gives rise to heat exposure and abrasion on the surface of the clinker cooler. Cast parts from materials 1.4777 and 1.4825, which retain their mechanical properties up to application temperatures of 900 - 1100 °C, are used here. This ensures that, even at these temperatures, the abrasion wear is kept on the lower shelf, allowing for service lives of 1 - 2 years.

Applications in the low-temperature zone

Both the input substances and the clinker are subjected to the process steps of separating and crushing in the low-temperature zone (temperatures <350 °C). Crushing causes the most wear on the corresponding machine components due to the high energy input required.

In hammer crushers, the swing hammers and impact plates are exposed to great impact loads. In addition, the swing hammers are exposed to high dynamic loads due to the high circumferential speeds of up to 70 m/s. In the manufacturers' standard configuration, these hammers are made of austenitic manganese steel. To optimise service life, bi-metal (composite casting) hammers are used.

Case study

Vautid uses hammers that are not manufactured from austenitic manganese steel, but from an improved process for composite casting. The company's product recommendation has already paid dividends for a plant in Guayaquil, Ecuador. Where the austenitic manganese steel hammers had a service life of 6 weeks, the composite casting hammers last for more than 46 weeks. This success has had a major effect on production in the form of increased productivity and reduced replacement costs.

Grinders

Today, ball mills, vertical mills and roller presses are used for fine-grinding limestone and coal/clinker.

Wear in ball mills occurs mainly on the grinding balls, which are replaced when the wear limit is reached. Worn rollers in roller presses can be regenerated or replaced using hardfacing materials.

Wear in vertical mills occurs on both the grinding plates and tyres. As an anti-wear measure, these are protected by the application of hardfacing materials.

Case study

Since 1998, Vautid has been regenerating vertical mills both for raw meal/coal grinding and, at a joint venture in Ecuador at Intervial, for clinker grinding.

In 2004, Vautid concluded a regeneration contract with a major cement producer in Guayaquil, which was to run for 5 years, to achieve a service life improvement of 30% within this period.

As early as 2007, the required improvement was achieved by making technical changes to hardfacing. As a result, the contract was extended until 2015.

The service life was further increased in 2008 by changing the hardfacing materials.

Vautid has demonstrated, using hardfacing thicknesses of up to 150 mm, that it is possible to hardface more than has been previously assumed, thereby achieving service life extensions and considerable cost savings for the operator.

The company's experiences in regenerating grinding plates and grinding rolls provided the basis for a project that began in 2007.

Vautid was commissioned to manufacture one grinding plate and two grinding rolls, which already specify the wear profile in the cast body. Before being used in the vertical mill, the grinding plate segments cast from Vautid W 73 alloy were hardfaced. This affords not only a better service life as a result of regeneration using hardfacing materials, but also a certain wear reserve in the cast part if, for production reasons, the replacement cannot be made in time.

This experiment has encouraged the company to explore this direction, and it is currently testing whether it is possible to manufacture the cast base body from cheaper materials.

Linings of impact plates/fans

When material is transported, surfaces are exposed to abrasion at various stations, such as transfer stations, chutes, as well as in suction pipes and the fans required for suction.

Composite wear plates are also used as an anti-wear measure, mainly for screens, hopper linings, vibration conveyors and slides.

Composite wear plates are produced economically using a special hardfacing technique that involves very high deposition rates at the same time as low intermingling with the base body. All weldable sheet steel types with a minimum wall thickness of 5 mm can be used as the base material. The applied layer is between 3 and 20 mm thick and is specially tailored to wear applications characterised by abrasion up to 750 °C. The metallurgy of the protective

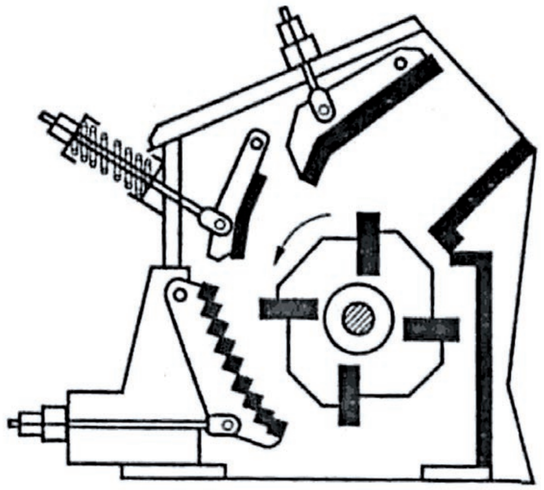

Figure 4. Hammer crusher.

Figure 5. Bi-metal hammer.

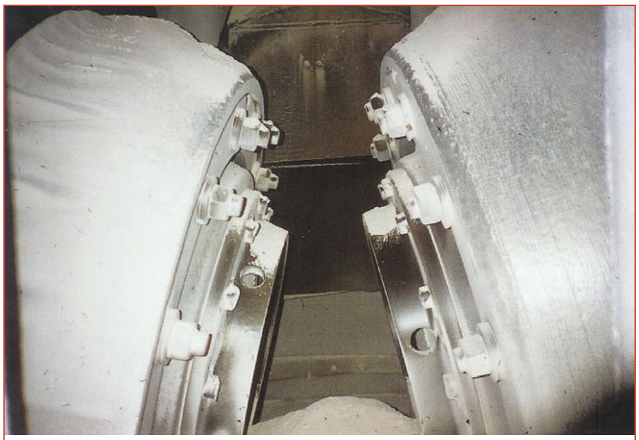

Figure 6. High-pressure grinding rollers: worn (left-hand side); regenerated (right-hand side).

Figure 7. Designs of wear plates for the feeding hopper (left-hand side) and fan (right-hand side).

layer on composite wear plates is identical to that of hardfacing materials.

Selection criteria for composite wear plates include:

- Large-surface wear prevention, as in feeding hoppers, chutes, slides or suction systems.
- Composite wear plates provide an economical solution for such large surfaces.
- They can also be used as structural elements with no substructure of their own.
- They are made to measure and can, if required, be partially repaired by means of hardfacing materials.
- Their high carbide content can be maintained even after repair.

Conclusion

Heat-resistant cast steel types are essential for deployment in the high-temperature zone, as they preserve both their resistance to scaling and their mechanical properties in high temperature ranges.

Applications in the low-temperature zone are mainly characterised by crushing. Chromium iron alloys are suitable for such applications, as they offer very good wear protection due to the hard carbides embedded in them. This materials group is produced as both a casting material and a hardfacing material. To ensure optimum wear protection, it is often advisable to use a combination of casting and hardfacing materials or various casting materials as a bi-metal (composite casting) in one part (cast steel and white cast iron).

To optimise the wear rate, base bodies for grinding tyres and plates can be prefabricated with an appropriate profile and then subjected to hardfacing. The use of chromium white cast iron for the base bodies of these grinding plates and tyres, which is available as an additional option for an emergency reserve, also provides good wear protection.

In the case of wear protection solutions for large surfaces, there is a preference for using composite wear plates and designs produced from them as a cost-effective solution. Composite wear plates allow the component to be repaired at any time.

If the various selection criteria are analysed and applied consistently to a specific wear problem, it will be possible to find long-term, wear-resistant solutions.