ICR article draft

Repair welding in VRMs

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Repair welding of rollers in vertical mills for the cement industry can be an effective way to extend the lifetime of grinding equipment, improve efficiency, as well as reduce vibrations and energy consumption, as VAUTID of Germany demonstrates below.

During the maintenance of grinding rollers, a different material is applied compared to the original material used when grinding equipment is initially delivered. Chilled iron casting is replaced by iron-chromium-carbon (Fe-Cr-C) hardfacing materials which have a hypereutectic structure, superior to that of the original casting materials. This results in a substantially longer serviceable life compared to the original component.

One might assume that a grinding tool could be regenerated as often as needed. However, experience shows that fatigue takes effect after the third or fourth time of rewelding (even in the case of the original base material) which means grinding parts must be renewed after the fourth regeneration of maintenance.

Figure 1 shows a worn grinding tool with a classical dune structure and a repair-welded grinding roller. With the exception of coal mills, these can be maintained in-situ, (ie, without being dismantled and removed) or by dismounting the grinding rollers so work can be undertaken in a workshop. This latter option can prove complicated and/or costly. Replacement parts are made in advance to ensure that production stoppages are kept to a minimum.

Execution of hardfacing

Resurface welding requires intensive preparation. The resurfacing of vertical rollers needs a mechanism that moves grinding rollers with diameters as large as 4m, although grinding rollers with a larger diameter are segmented. If the grinding rollers have a diameter of 1500mm or less, they are made of one single casting. The same also applies to the grinding table which comprises single-components and segmented equipment, depending on the size.

The three most important points in the metallographic process of welding that should be checked in theoretical and practical terms before resurfacing is carried out on:

- base material
- welding process
- welding resurfacing material.

Figure 1: maintaining grinding equipment

The base material

There is no easy way to check the base material for weldability with Ni-Hard casting materials. In any event, it is necessary to distinguish joint weldability from resurfacing weldability. Materials with a carbon content >2.5 per cent, nickel content of 3-7 per cent and chromium content of 1-10 per cent are generally not suitable for joint welding (see Figure 2).

Beyond this, there are very strict rules when joint welding steels because the carbon content is so high. However, the Fe-Cr-C-status shown in Figure 2 highlights that the major phase shares of austenite (y phase) can result in satisfactory welding results with the wear-resistant alloy discussed above. On the other hand, the yellow line outlines resurfacing by weldability. The green range shows resurfacing welding that has been carried out frequently and successfully.

Since different physical laws apply when resurfacing using the welding process, it is still possible to weld onto the base material in certain areas if welding is carried out quickly (and at a low linear energy). An austenite with a low carbon content is joined with a hardfacing material based on metals science. To achieve a reliable joint between the base material, so-called buffer materials (austenites which are low in carbon) are advisable because they join the base Ni-Hard material perfectly with the hardfacing material containing Fe-Cr-C. These welding resurfacing materials also contain as much as 4.5 per cent C and 30 per cent Cr, making it possible to surface in several layers.

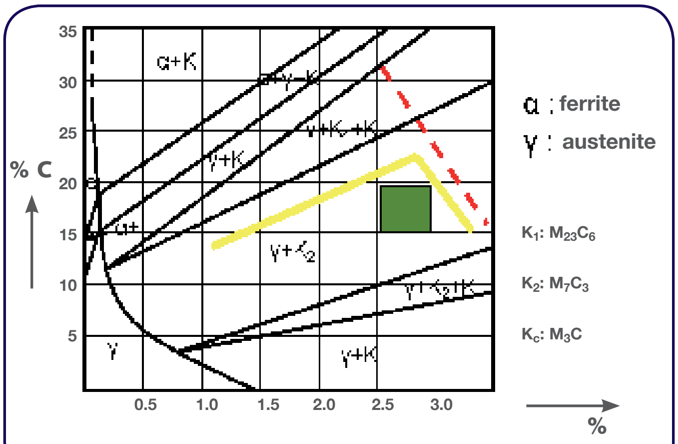

Figure 2: isothermal section through the Fe-Cr-C status figure at 1000°C

Finally, it is necessary to preheat the base material due to the aforementioned high carbon content, although with such a high-alloy content, it is not useful to calculate any carbon equivalent. The empirical value of the carbon equivalent was developed for low-alloy construction steels so VAUTID recommends heating the base material to 150-200˚C when the roller is running.

The welding process

Generally, shielded metal arc welding is used with flux cored wire (welding process 114 conforming to DIN EN ISO 4063). Furthermore, gas shielded metal arc welding with flux cored wire, is also possible but is seldom used because it requires expensive apparatus for the shielding gas with in-situ welding (process 137). This is why self-protecting flux cored wires are used for open arc-welding, applies to both in-situ welding and maintenance carried out in workshops.

The weld metals can also be protected with gas or powder, although these are rarely used with the aforementioned roller mills. Finally, UP welding (process 125) has also been successfully used during the repair of coal roller mills. Generally, ɸ2.8mm or ɸ3.2mm thick flux cored wires are used as this allows efficient welding resurfacing with a medium deposition rate of 12-15kg/h.

Welding resurfacing material

Welding resurfacing materials can be tailor-made. Plant maintenance personnel determine the collective stress that primarily comes from the abrasion caused by movement of grinding rollers. Iron materials with a high level of chromium and carbon and those mixed with niobium are advisable with this type of abrasion – and not just primary chromium carbides but also primary niobium carbides. These special carbides have a microhardness of 2200 Vickers which makes them excellent for milling these mineral materials. Finally, collective stress consists of abrasion and shearing forces.

Figure 3 shows the structure of a material containing Fe-Cr-Nb-C with a total hardness of 63-65 HRC. This material has become expensive due to the niobium additive, therefore only the materials containing chromium carbide are used.

Examples of extending serviceable life

South America

The wear and tear of a 0.7-0.8Mta Gebr Pfeiffer MPS 2650/1750 mill at a cement plant in South America was approximately 3g/t of milled raw meal prior using VAUTID's flux cored wires for rewelding. Surfacing the outer wear sections and tray, in accordance with customer specifications, improved the wear and tear to 1.7g/t of ground material while boosting annual production. It also reduced vibrations in the roller mill.

Israel

VAUTID was also tasked with refurbishing a Loesche LM 56.3+3 VRM cement mill in collaboration its local business partner. VAUTID's team surfaced the rollers and table in-situ at the cement factory. Prior to selecting the hardfacing alloys to be used,

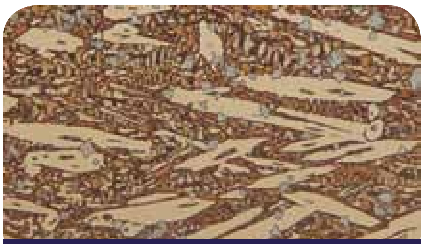

Figure 3: the structure of an Fe-Cr-Nb-C alloy

the company undertook wear experiments with the ground material at its laboratory. Based test results VAUTID-100 and VAUTID-143 were selected.

In-situ re-welding

Grinding equipment surfaced with VAUTID materials in vertical mills achieve 2-3 times higher service life compared to white iron casting alloys originally used. This solution not only makes it possible to significantly reduce maintenance costs but also improves production efficiency, substantially reduces vibrations and scales back milling energy costs.

Summary

The following knowledge is necessary when refurbishing grinding rollers:

• Expertise for operating appropriate machines & apparatuses

A correspondingly large rotating device is needed for the grinding table running in the horizontal direction which as many as three manipulators can simultaneously deposit hardfacing materials. A simple rotating device is sufficient for the grinding rollers functioning vertically, half of which is in a pit. That means that the machine operator can reach and look into the highest point of the roller (the point of resurfacing by welding).

• Knowledge of metallurgic properties of the base materials to be welded

The initial equipment for the grinding tools generally consists of Fe-Cr-C which is regenerated after the initial milling wear with chromium-carbon hardfacing alloys. Unlimited repair is not possible because the basic material is fatigued after the 3-5 regenerations. Microscopic cracks then bring about macroscopic faults, cracks and break-outs.

• Knowledge of the benefits and drawbacks of the various welding processes

Figure 4 (top left): castings supplied before surfacing alloy

Figure 5 (top righ): grinding table segments supplied with VAUTID-100-Mo surfacing

Figure 6 (bottom): vertical roller segments regenerated with VAUTID-100-Mo

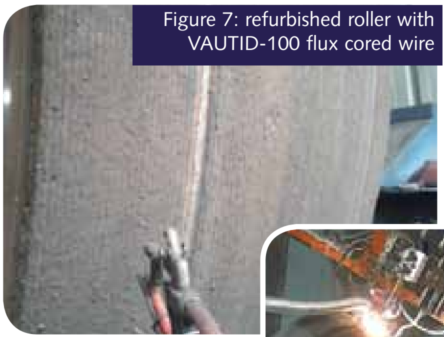

Figure 7: refurbished roller with VAUTID-100 flux cored wire

Figure 8: in-situ re-welding in the cement mill

In most cases, open-arc welding is used, although MIG welding or submerged arc welding are also possible. Although these processes can be somewhat more expensive, there is a better welding quality with the latter two processes.

d) Know-how of the properties of welding resurfacing materials to meet milling and wearing characteristics

Welding resurfacing materials can be used tailor-made on the collective wear. In this case, this is abrasion without any temperature or corrosion stress worth mentioning. A FeCrC hard alloy whose pure weld deposit has a hardness of approximately 63 HRC is the right solution since primary carbides in the matrix extend the service lifetime of the grinding roller and table many times over.

Conclusion

Many years of experience from various countries and areas of application provide enable VAUTID to offer wear solutions to meet customer-specific VRM requirements. One of the main services is a cost-analysis which takes into account maintenance expenses, increases in the mill's production capacity and reductions in power consumption, each of which have a substantial economic impact on the operation of roller

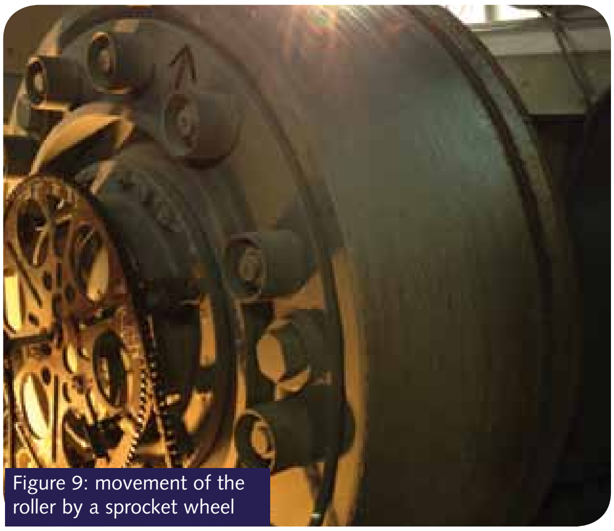

Figure 9: movement of the roller by a sprocket wheel