Improved guide rollers for wire rod mills

Titanium carbide has proved to be a cost-effective material for the manufacture of guide rollers for wire rod mills, having low density, excellent oxidation and wear resistance, coupled with relatively good resistance to thermal shock.

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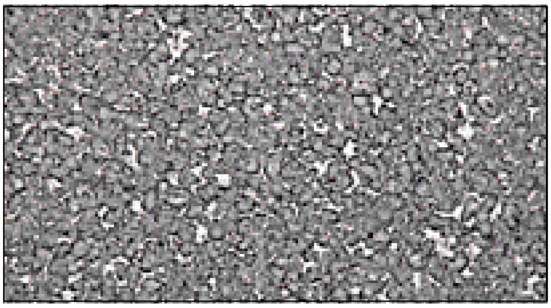
Sintered titanium carbide has been used extensively since the early 1980s for demanding wear-resistant applications; and in particular, in environments characterised by high temperature and oxidation. Thanks to its physical characteristics, especially its low density, titanium carbide (TiC) has been successfully applied in the manufacture of cassette guide rollers for hot steel rolling.

Brief history of titanium carbide

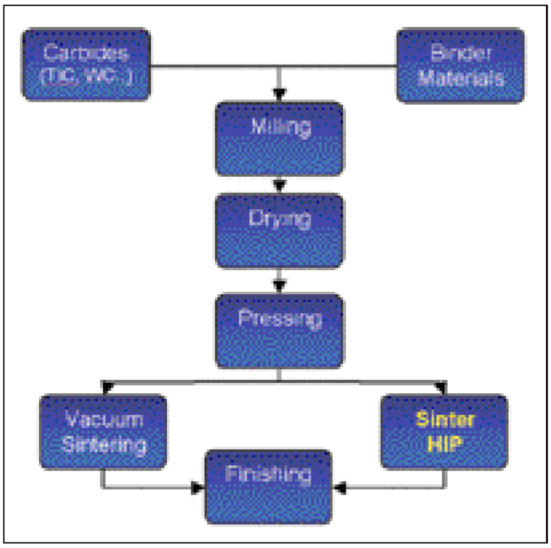
Cemented carbide, or 'hardmetal' as it is often called, is a material made by cementing very hard tungsten monocarbide (WC) grains in a binder matrix of tough cobalt metal by liquid phase sintering. The beginning of tungsten carbide production may be traced to the early 1920s for use in tungsten wire drawing. These attempts led to the invention of cemented carbide, which was soon produced by several companies for applications where its high wear resistance was particularly important.

The use of TiC with, or instead of, WC followed, due to the high indentation hardness of titanium carbides, as well as the greater availability and lower cost of the raw material titanium dioxide. Various TiC grades were introduced from the 1960s, when nickel replaced cobalt as a more efficient binder. Toughness was further improved with the introduction of titanium nitrite in 1970, while the introduction of chromium and nickel further increased their resistance to oxidation and corrosion.

TiC hardmetals have a relatively simple metallographic structure, but for quality control, the grain size and porosity must be controlled (see *Figure 1*). In particular, porosity is the main quality problem since even vacuum sintering cannot completely overcome the problem of oxygen pick-up. However, the hot isostatic pressure sintering process (HIP), introduced in the late 1980s, significantly improved the final quality of TiCs, by solving the porosity problems (see *Figure* 2).



● **Figure 1** ***TiC microstructure***



● **Figure 2** ***Carbide sintering process***

Titanium alloys in guide roller applications

Thanks to its low density, high wear, oxidation and temperature resistance, several different titanium based alloys are available for guide roller applications, but they can all be classified in two categories:

- **Iron or steel matrix carbides, such as Ferrotic and Ferrodur-type alloys** These alloys are based on steel powder metallurgy with the titanium carbides dispersed in an iron-based matrix and sintered. These materials are magnetic and, in general, can be heat treated to reach hardness levels of around 60-65HRc. In the

● Figure 3 ***ATOM rollers***

annealed state, hardness can be 45-50HRc for easy machining by lathe.

- **The Ni-Cr-W matrix carbides such as the ATOMAT product ATOM** In this case the product is a true hardmetal in which a hardness of approximately 86HRa (approx. 70HRc) is reached by sintering. They are non-magnetic, non-heat treatable and cannot be turned by lathe, but must be ground by diamond wheels.

The characteristics that are common to both the above carbide types and which makes these materials particularly suitable for guide roller application are:

- Low density
- Relatively good resistance to thermal shock
- Excellent oxidation resistance
- Excellent wear resistance

The density of TiC of approximately 6.5g/cm^3, ie, lower than steel and less than half that of tungsten carbide, means very low inertia and lower loads for a longer bearing life. Even with the introduction of titanium nitrite in new TiC grades (ATOM type) for improved toughness, some plant practices must be applied to reduce thermal shock during operations.

The basic difference between the two types of cemented TiC is thermal stability. As the Fe-based alloys are heat treatable, this makes the material easily worked during manufacture, since it can be machined at low hardness before heat treatment. This can, however, affect the performance in high-temperature applications, where it can lose hardness and wear resistance.

In the Fe-free Ni-based alloys (ATOM type) hardness is a 'built-in' characteristic and not the result of heat-treatment such as plating or nitriding, to produce a superficial hardness. This means a material with isotropic mechanical characteristics, metallurgically and dimensionally stable up to 900-1,000°C, and with excellent resistance to oxidation both at normal and elevated temperatures. This makes the material workable only by diamond grinding wheels, but it does achieve consistently high performance.

Performance of TiC guide rollers

Maximum cost-effectiveness of TiC rollers is usually achieved in the finishing block stands and wear resistance is excellent for both carbide types. The wear life of TiC rollers is typically 10–30 times longer than steel rollers, but as the overall wear life depends on several operating parameters, including the specific maintenance practice of each plant, there is a high variability even for similar applications

Both the alloys have been on the market for more than 20 years and, in general, the cost-effectiveness of the ATOM type is universally recognised, since wear resistance of the carbides results in approximately 2–3 times longer roll life, when compared with the Ferrotic type. Sometimes the roller material used is related to other parameters and Ferrotic type rollers may be preferred because they can be machined by lathe.

In reality, the grinding operations on these small rollers are extremely easy and can be performed by every type of grinder generally available in the roll maintenance shop. Electroplated shaped diamond wheels can be used for accurate, fast, cheap and trouble-free grinding operations. Another option is to use specialised grinding centres. These centres need not necessarily be very close to the plant since guide rollers are small and very light, hence the shipping costs, even by air, are usually negligible.

The wear life is generally measured as tonnage for one life, ie, rolling in the mill before removing to re-dress the roller groove. Type of re-dressing depends on the maintenance practice of each plant and can be:

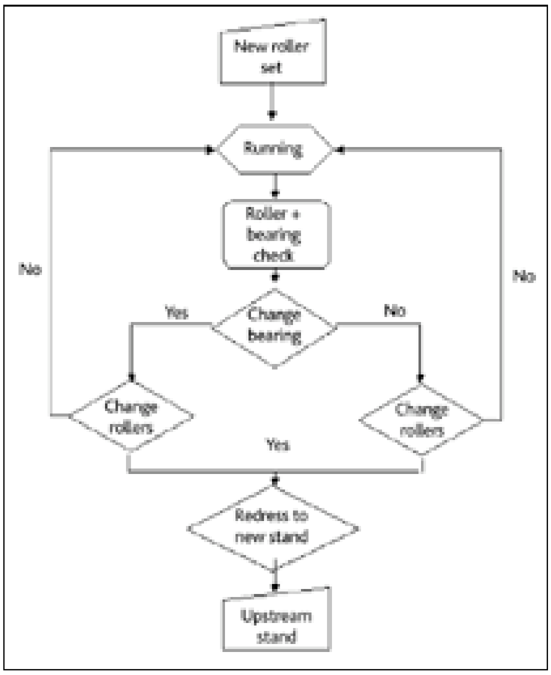
- Outside diameter dressing to keep the same groove at the same stand
- Groove dressing to move the roller upstream from the previous stand

Very frequently the maintenance practice is a combination of the above (see *Figure 4*).

In reality, a maintenance practice is established which takes into account the bearing life and rolling ring wear life to optimise the mill down time. Sometimes wear rate is reported as the number of tonnes per millimeter of roll diameter removed. This is simply calculated considering the average amount of material dressed off the roller outside diameter at each life and the tonnage rolled for each re-dressing. The usefulness of this method may depend on whether the rollers are run for low tonnages and removing a very minimum layer of material during re-dressing, or whether the roller is run for large tonnages with a more consistent layer removal at each re-dressing operation.

ATOM guide rollers: a case study

Plant characteristics The case reported refers to a plant that has used ATOM rollers for high-speed blocks since the late 1980s (see *Table 1*). In 1998, a



● **Figure 4** ***An example of a maintenance cycle***

comparative test was carried out between ATOM-, stellite-, Ferrotic- and D7-type, rollers which confirmed cost effectiveness of ATOM rollers.

Maintenance practice Rollers are usually re-dressed in the following sequence:

- Twice with removal of approximately 0.25mm each time both on outside diameter and profile to use the rollers in the same position
- Thereafter, re-dressing only on profile only to move the roller upstream (for example, from stand 24 to 22)

In such a way the rollers are ground a total of 11 times; 8 times at the same stand (2 times for each of 4 passes) and 3 times to pass from one stand to the previous one.

Practices for correct application of TiC guide rollers TiC guide rollers are relatively expensive, so maximum care must be used to avoid damage and maximise wear life. This includes care when handling to avoid dropping. The mill operating conditions must be such as to avoid local overheating and thermal shocks, hence special attention must be paid to cooling and bearings.

The key point for effective roller cooling is rapid extraction of heat from the surface of the rollers that come in contact with the hot steel on each revolution. The aim is to keep the maximum surface skin temperature on each revolution just slightly higher than the inner roller body temperature, in order to minimise thermal fatigue and risk of damage. Therefore, in the pass area there must be a high volume of water at a relatively low pressure, which should be sufficient to break the vapour barrier but not so high that the water bounces back out of the pass without first extracting some of the heat from the hot surface. This water cooling must then remain on for three to four minutes, even after the mill has stopped.

To prevent roller damage, bearing efficiency must also be checked and confirmed. The guide rollers must be pre-greased with high-performance grease on assembly into the guide. This does not affect the automatic on-line air/oil lubrication since the grease will melt away and the air/oil takes over. The air/oil lubrication must be fed through the centre of the guide roller pin or adjacent to the roller pin and the guide roller bearings must be pre-loaded. Polyamide cage bearings must be used which must be replaced after approximately 20 hours or 1,500–2,000t. This applies to all the block stands.

In general, when bearings are replaced, the rollers are inspected and re-used if wear is not excessive. Re-dressing of ATOM rollers must be carried out by grinding with diamond wheels. Both plunge and contour grinding can be used and typically a layer of 0.25mm is removed at each operation and rollers can be redressed approximately 8–10 times.

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Parameter	Data
Morgan mill	10 stands
Mill speed	95-100 m/sec.
Guide roller stands	18-20-22-24
Guide rollers	Outside diameter 54.1mm, thickness 25.4mm
Yearly average production	450,000t/y
Guide rollers grade	TiC ATOM supplied by ATOMAT
Average ATOM guide roller consumption	200 pieces/yr
Tonnage for each new roller couple	4,500 t/couple
Tonnage between re-dressing	4,500 t
Number of lives	11
Discharging diameter	52mm
Tonnage for the whole roller life	50,000t

● **Table 1** ***Plant details and ATOM guide roller wear data***