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TITANIUM CARBIDE GUIDE ROLLERS: OPERATIVE BENEFITS AND MAINTENANCE PRACTICES*

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Abstract

Sintered titanium carbide has been extensively used since the early 1980s for demanding wear-resistant applications and, in particular, in environments characterized 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. However, the peculiar characteristics of the sintered Ti carbides make it difficult their redressing and hence this has always represented the limit for a more extensive application. Very often iron based alloys are preferred even if, in general, they are less cost effective just because they are easier to be redressed by turning. The availability of a simple, compact, fully automatic and reasonably priced CNC machine; specialized in the grinding of guide rollers and able to operate accurately and efficiently -both in contour and in plunge- can definitively solve TiC's redressing problems and render its use even more widespread and attractive.

Keywords: Titanium Carbide Guide Rollers; Carbide redressing; AT701E CNC Grinding Machine.

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1 INTRODUCTION

In this study, we'll summarize the state of the art of the application of the sintered Titanium Carbide in the guide rollers for high speed rolling mills. The advantages and the cost effectiveness of this material compared with high alloy steel, as well as to other Titanium Carbide Iron based alloys, are well known. Among the few TiC application limits are the speed of the mills (they are less cost effective for low speed mills), the efficiency of the cooling system (they are extremely sensitive to overheating and intensive thermal cycles) as well as on the redressing operation, because such material has to be ground with diamond wheels.
While the first two points are well known and can be clearly evaluated in the selection of the guide rollers material, the last point – their redressing – has always been a topic that discouraged their application when the roll shop was not properly equipped or the operators not enough skilled. Unlike steel or Carbide iron based rollers, the Sintered Titanium Carbide rollers shall be redressed by means of grinding with diamond wheels. Generally, the large grinding machines used for the finishing rings have limited spare time for other services and the small dimensions of the rollers may be not compatible with these machines.
Atomat designed a small grinding machine (the new AT701E CNC) that is a numerically controlled machine with very limited dimensions, suitable to overcome this restriction.

2 MATERIAL AND METHODS

2.1 ATOM TiC GUIDE ROLLERS

Cemented carbide, or `hardmetal` as it is often called, is a material made by cementing very hard tungsten monocarbide 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, when a German electrical bulb company, looked for alternatives to the expensive diamond drawing dies used in the production of tungsten wire. These attempts led to the invention of cemented carbide, which was soon produced and marketed by several companies for various applications where its high wear resistance was particularly important.
The use of TiC along with or instead of tungsten carbide followed, mainly because of its high hardness and the weight characteristics. 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 purposes, grain size and porosity must be strictly controlled. (See Figure 1)

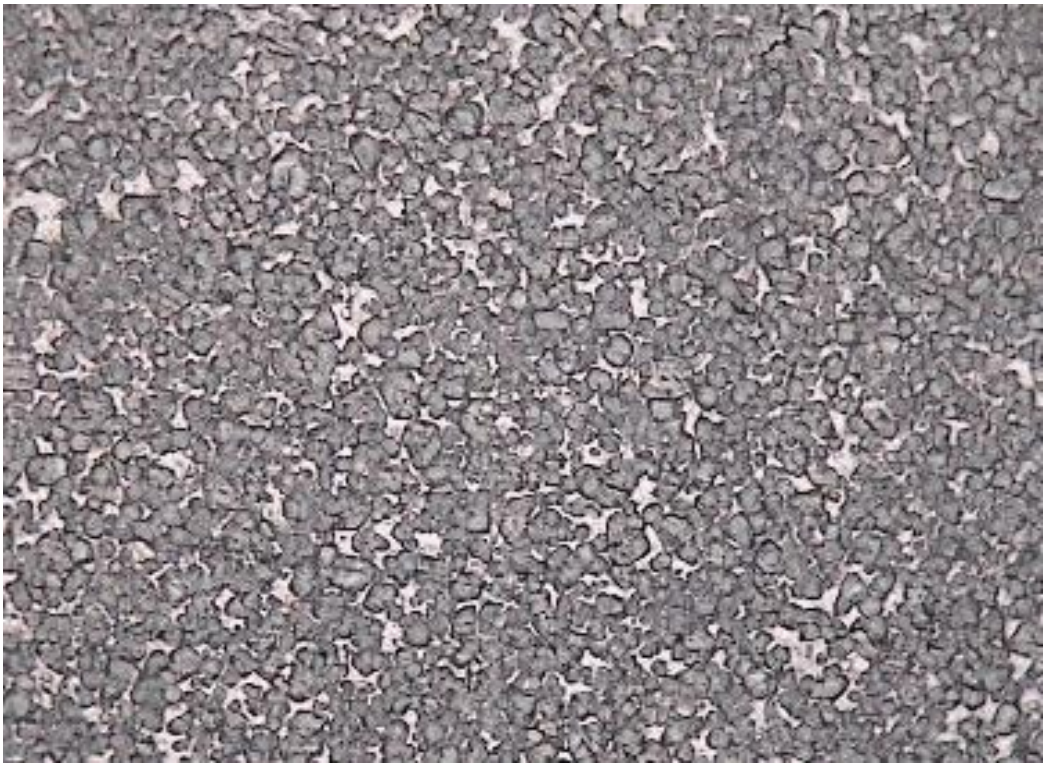


Figure 1: TiC microstructure

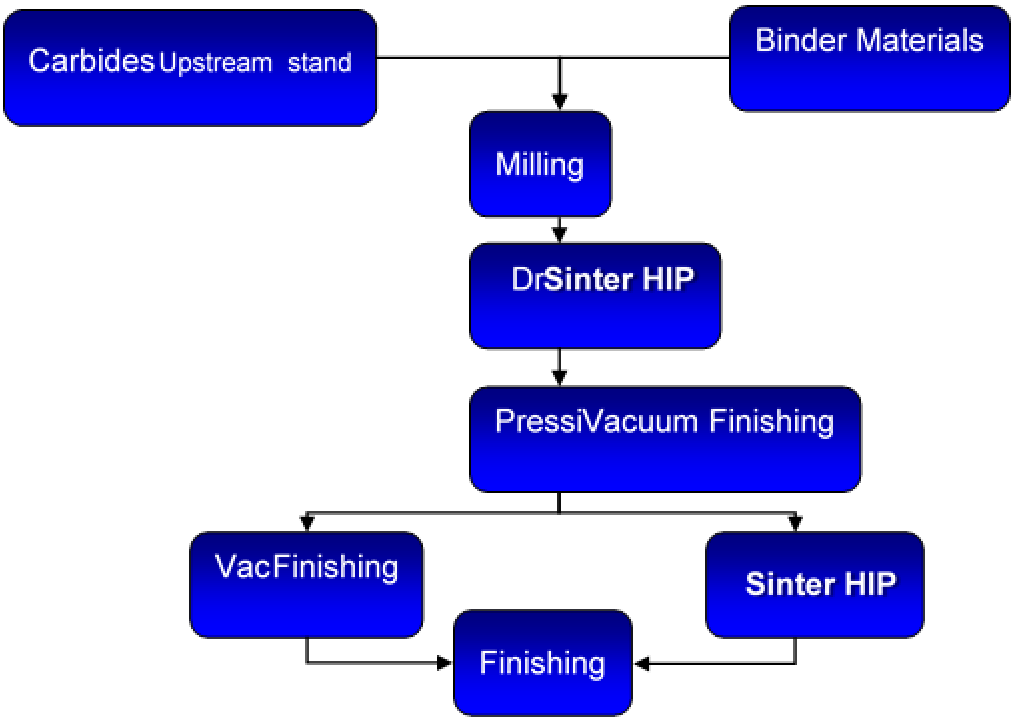


Figure 2: Carbide sintering process

2.2 TITANIUM ALLOYS IN GUIDE ROLLER APPLICATIONS

Thanks to its low density, high wear, oxidation and temperature resistance, several different titanium based alloys are today available for guide roller applications, but they can 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 60-65 HRc. In the annealed state hardness can be 45-50 HRc 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 86 Hra (approx. 70 HRc) 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 which are common to both the above carbide types and which makes these materials particularly suitable for guide roller application are namely:

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

The low density of TiC of approximately 6.5 g/cm^3, i.e lower than steel and less than half of the tungsten carbide, means very low inertia and lower loads and provides longer bearing life.

Even with the introduction of titanium nitrite in new TiC grades to improve toughness (ATOM type) nevertheless, some plant procedures must be employed in order to reduce thermal shock during operations.
The basic difference between the two types of cemented TiC is the thermal stability. The Fe-based alloys are heat treatable, this make this material easily wrought during manufacture, since it can be machined at low hardness before heat treatment. However, this affects the performance at high temperature because it can loose hardness and wear resistance.
In the Fe-free, Ni-based alloys (ATOM type) hardness is a `built-in` characteristic and not the result of processes like heat-treatment, plating or nitriding. This endows the material with isotropic mechanical characteristics, metallurgical and dimensional stability up to 900÷1000 °C and with excellent resistance to oxidation; both at normal and elevated temperatures. This makes this material workable only with diamond grinding wheels, but assures achieving consistent high performances.

Picture 1 – A cluster of ATOM TiC Guide Rollers

3 RESULTS AND DISCUSSION

3.1 Performance of TiC guide rollers

A maximum cost effectiveness of the TiC rollers is usually achieved in the finishing block stands and the wear resistance is excellent for both carbide types. The life of TiC rollers is typically 10 to 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 uses.

The mill operating conditions must be such as to avoid localized overheating and thermal shocks. This means that special attention must be paid to the cooling and the 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 at each revolution. The aim is to keep the maximum skin surface temperature at each revolution just slightly higher than the inner roller body temperature, in order to minimize the thermal fatigue and the risk of damage.
Therefore, in the pass area there must be a high volume of water at a relatively low pressure. The pressure level should be sufficient to break the vapor barrier, but not so high that the water bounces back out 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-lubricated with high performance grease during their assembly into the guide. This does not affect the automatic on-line air/oil lubrication as the grease will melt away and the air/oil takes over. The air/oil lubrication must be fed through the center 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÷2.000 tons. This applies to all the block stands.

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

3.2 GRINDING OF ATOM TIC GUIDE ROLLERS

The wear life is usually measured as tonnage for one go, i.e. tons rolled in the mill before removing the roller to re-dress its groove. The type of re-dressing depends on the maintenance practice of each plant and can be summarized as follows:

- 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, to optimize the mill down time, a maintenance practice must take into account the bearing life and the rolling ring wear life.

Sometimes the wear rate is reported as the tons. of bars per millimeter of roll diameter removed. This is simply calculated considering the average amount of material ground out of the roller outside diameter for each cycle and the tonnage rolled for each re-dressing. The effectiveness 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 substantial layer removal at each re-dressing operation.

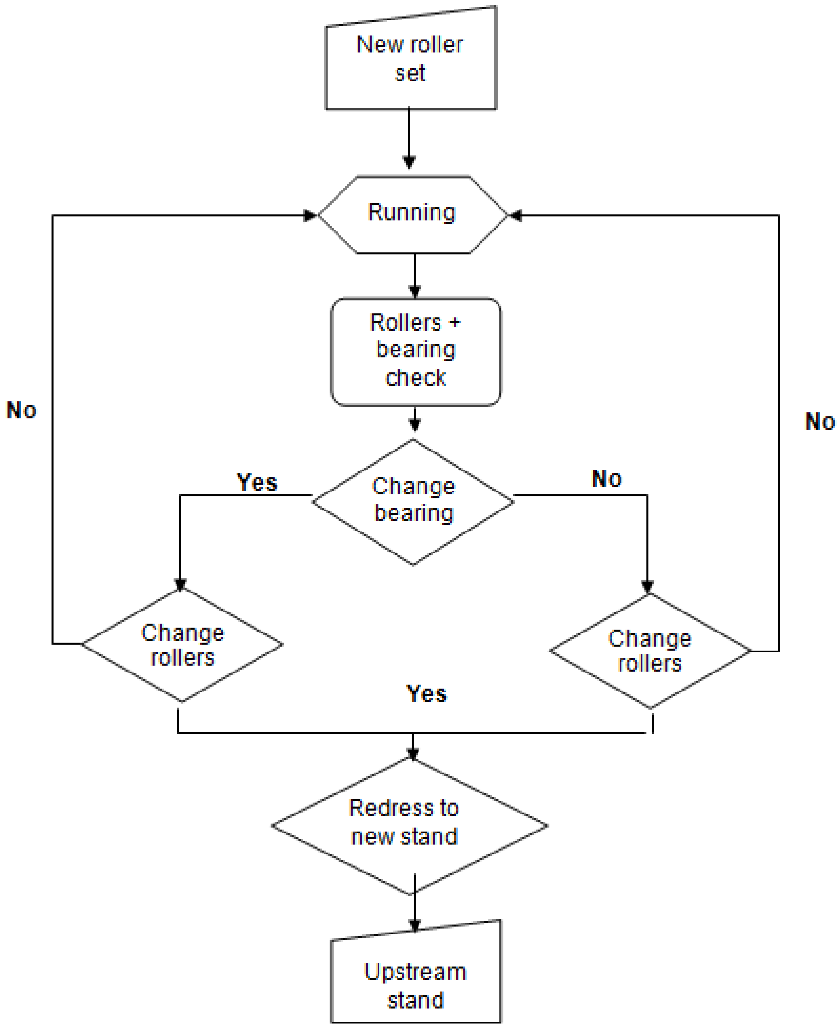


Figure 4 Example of a maintenance cycle

3.3 ATOMAT AT701E CNC GRINDING MACHINE

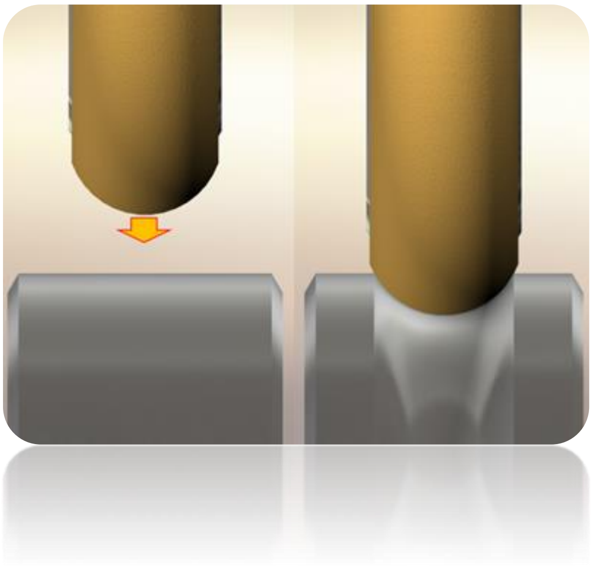
Sometimes the choice of the roller material is related to other parameters than cost effectiveness, and Ferrotic type rollers may be preferred because they can be machined with a lathe.
In reality, the grinding operations on the small TiC rollers are also extremely easy and could be performed with every type of grinder commonly available in any roll maintenance shop.

Anyway, to overcome this limitation, today Atomat has made it available a new CNC grinding machine tailored for this particular application (See Picture 2).

Picture 2 - Atomat AT701E CNC

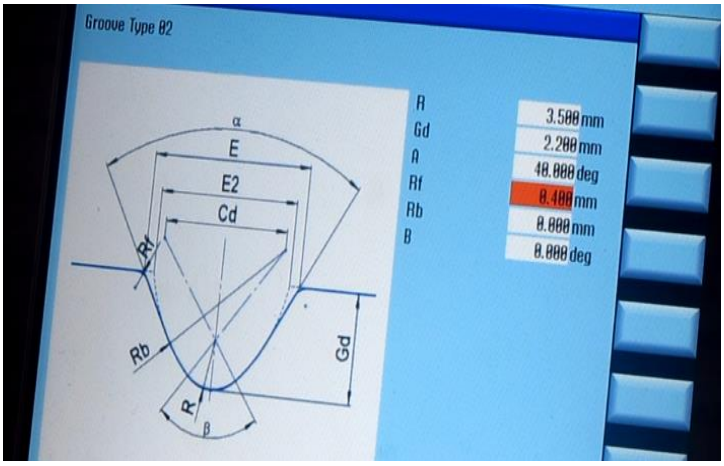
The Atomat AT701E CNC is in fact a grinding machine specifically designed for the machining and redressing of carbides guide rollers.
The machine is powered with the SIEMENS 840D SL control and can perform contour grinding with extreme accuracy. It operates with electroplated diamond, metal/resin bond diamond and CBN grinding wheels, with an outside diameter of 150mm.
The *electroplated wheels* are generally preferred since they have an extremely long wear life and do not require any maintenance during their operating life.
The machine can operate both in *contour* and *plunge* grinding. When activated in contour, the machine is able to cut *all possible profiles, basically with the same grinding wheel*.

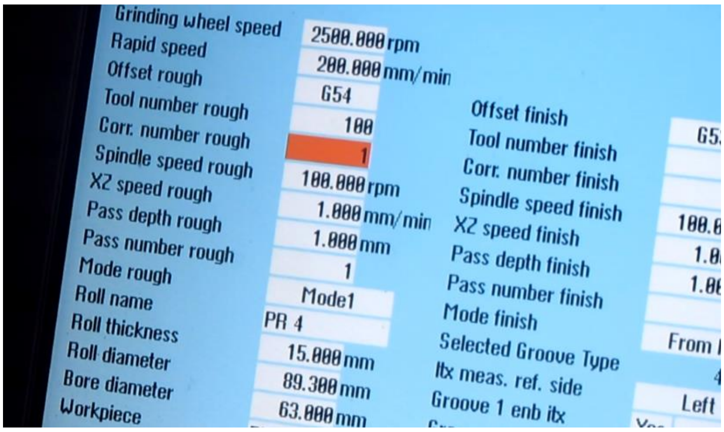
Picture 3 – Contour Grinding



Picture 4 – Plunge Grinding

Being the regrinding cycle fully automatic, the machine requires just a limited operator’s attention and thus, it can be installed among other existing CNC machines without increasing the number of operators in the Roll Shop.
For the definition of the roll groove profile and machining parameters, our AT701E functions with an easy and ready-to-use operator interface that makes the programming operations extremely fast that do not require particularly skilled personnel.





Picture 5 - AT701E Guided Interface

This grinding machine is very small and compact and can be easily set up according to the most ergonomic fashion to avoid operator's to walk between the machines that are under his control (See Picture 6). Its small dimension and the optimization of the components make the investment for this machine very affordable, easily justified and with a very short pay-back period.

Picture 6 - AT701E General Assembly

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4 CONCLUSION

The Titanium Carbide has demonstrated to be a cost effective material for the manufacture of guide rollers used in modern wire rod mills because of its low density, excellent resistance to wear and oxidation, coupled with relatively good resistance to thermal shock. As a general rule when bearings are replaced and if wear is not excessive the rollers are inspected and reused. Re-dressing of ATOM rollers must be carried out grinding them with diamond wheels.
Nowadays these redressing operations can be easily performed with a small, compact and user friendly machine, the latest grinder Atomat's AT701E CNC which allows both plunge and contour grinding of the guide rollers.

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