Metco has left the Sulzer Group and is now part of the Oerlikon Group.

oerlikon metco

Modern coating solutions for the machining industry

Longer lasting tools

In metal processing, surface solutions such as PVD coatings (physical vapor deposition) improve tools so much that customers can benefit from enormous economic advantages. Optimizing tools for their use is a complex task, however. Standard coatings can help, but really impressive results can only be achieved if all the factors are coordinated with one another, from the starting material up to the posttreatment.

Machining is a metal-cutting process that has to fulfill increasingly high demands with regard to productivity and processing speed. The friction arising during the process and the wear on components and tools are major loss factors. According to the German Society for Tribology, a loss of about 5% of gross social product arises annually in industrialized countries through the effects of friction and wear alone.

Tool coatings counter these mechanisms and are thereby essential nowadays in machining. As a provider of innovative surface technologies, the Thin Film business unit of Sulzer Metco has been developing tailor-made system solutions for many years to make tools more resistant, more productive, and longer lasting. The special feature of Sulzer's holistic approach is the consideration and streamlining of all the influencing factors. Start-

Tool coatings are essential nowadays in machining.

In machining, everything depends on the optimal interplay of all the parameters of the tool, the coating, and the material.

How does wear on tools arise?

During the machining (the removal of chips), the following wear mechanisms take place in the area the tools contact the material being worked on due to the friction processes and the thermal and chemical stresses:

- Adhesion between chips and the cutting surface
- Abrasion through hard materials within the material
- Tribochemical reactions (chemical material behavior due to mechanical action and high temperatures)

These tribological stresses largely characterize the efficiency of tools because they reduce the cutting forces and shorten service life.

A surface coating may reduce the impact of the tribological stresses, while the base material of the tool takes over the supporting function and absorbs the mechanical stresses. In addition to increased productivity, improvement in the tribological system also leads to savings in material and energy.

ing from the application-specific requirements, Sulzer finds the best-possible combination of

- Pre- and posttreatment of the tool surface
- Coating material
- Layer architecture
- System technology with which the coating will be applied

Targeted pre- and posttreatments

The cutting tool is subjected to high pressure (more than 2 GPa), high temperatures, and thermal cycling stresses in the modern machining process. The pre- and posttreatment—as well as the coating—must therefore also be adapted to the application.

There are various pretreatment methods available that prepare the tools for a subsequent coating process and significantly improve the coating adhesion at the same time. Together with the coating, a preparation of the cutting edge of the tool leads to increased cutting speeds, feed rates, and longer service lives. The posttreatment (edge preparation, surface treatment, and structuring) also plays a decisive role, in particular, in avoiding the initial wear, which can occur, for example, through cutting-edge buildup (adhesion of material from the workpiece to the cutting tool).

Numerous tests have shown how great the impact of the pre- and posttreatment of tools can be on productivity. For example, performance gains of more than 100% in gear-cutting tools can be achieved through specific preparations.

Specific preparations can improve tool performance by more than 100%.

Coatings for demanding working conditions

The requirements that are placed on coatings can be very different. As high temperatures arise at the cutting edge during machining, high resistance to thermal wear becomes extremely important. The following properties are expected from modern coatings:

- Excellent high-temperature properties
- Resistance to oxidation
- High hardness, even at high working temperatures
- Microductility (plasticity) through a nano-structured layer design (Figure 1)

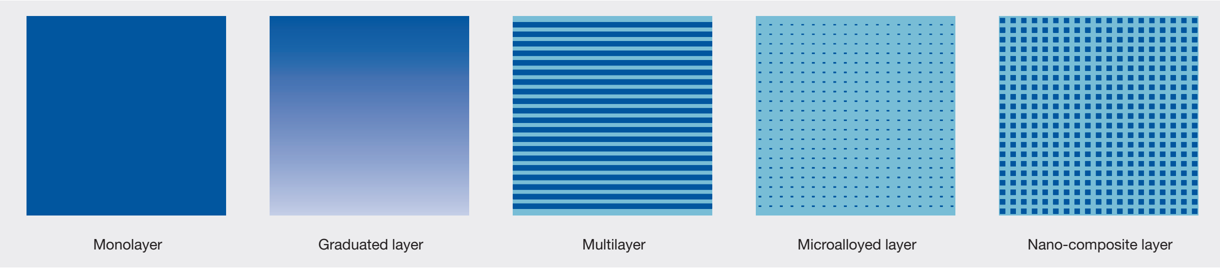
In the case of high-performance tools, optimal adhesion of the coating and well-adapted residual stress are decisive factors. This applies, above all, to the interaction between the base material and the applied coating. The coating material should have the least possible affinity to the material being worked on. In this way—with suitable cutting geometry and by smoothing or polishing of the coating—the adhesion tendency can be significantly reduced.

Tailor-made coatings

Aluminum-based coatings, such as AlTiN (titanium aluminum nitride), are often used in the machining industry. In these aluminum-based coatings, a thin but dense aluminum oxide layer forms as a result of the high temperatures during the machining. This layer then continually and independently renews itself and protects the coating and the base material below it from oxidative decay. The required hardness and resistance to oxidation can be adjusted through a variation of the aluminum content and the layer morphology. The resistance to oxidation, for example, can be improved through an increased aluminum content, nano-structuring, or microalloying (i.e., alloying with low-percentage element proportions).

In addition to the chemical composition of the material, the layer architecture can also considerably alter the properties of a coating. Different tool properties arise depending on the distribution of the elements in the microstructure of a layer (Figure 1). Today, several individual layers with different chemical compositions can be combined to achieve customized

1 Functional coating properties, such as the layer hardness, the phase stability, and the tribological properties, can be adjusted by a different distribution of the elements within the layer.



properties. This trend will increase even more in the future—in particular, through new system and process technologies, such as the HI3 technology.

How can costs be reduced in machining?

An important cost factor in the production cycle is the service life of the tools. Among other things, this is understood as the period during which a machine can work without interruption before it requires maintenance. The longer the service life, the lower the costs that arise for production interruptions and maintenance work will be. The use of coatings increases the service lives of the tools—even at high process temperatures—and thereby considerably reduces the costs. In addition, fewer lubricants are needed. This not only reduces the material costs but also helps protect the environment.

Coating technology for the future

HI3 technology, developed by Sulzer, combines three highly ionized arc processes:

- AEGD (arc-enhanced glow discharge): plasma etching process for good layer adhesion (can also be used for the pre-ionization of reactive gases during the coating)
- HIPAC (high-ionization plasma-assisted coating): highly ionized sputter process
- APA Arc (advanced plasma-assisted arc): highly ionized arc process.

The combination of high-ionization-sputter and high-ionization-arc processes makes it possible to achieve layer architectures that could not be realized previously. Up to now, many alloys could only be partially deposited with the arc process alone. The combination of the arc process with the HIPAC process brings advantages, as this process can evaporate a considerably larger spectrum of materials, such as SiB (silicon-boron), B4C (boron carbide), and others. In this way, the process can open up completely new application fields. With the METAPLAS.DOMINO series, Sulzer offers modular coating systems with which the HI3 technology can be implemented (Figure 2).

The HI3 process technology of Sulzer opens up completely new application fields.

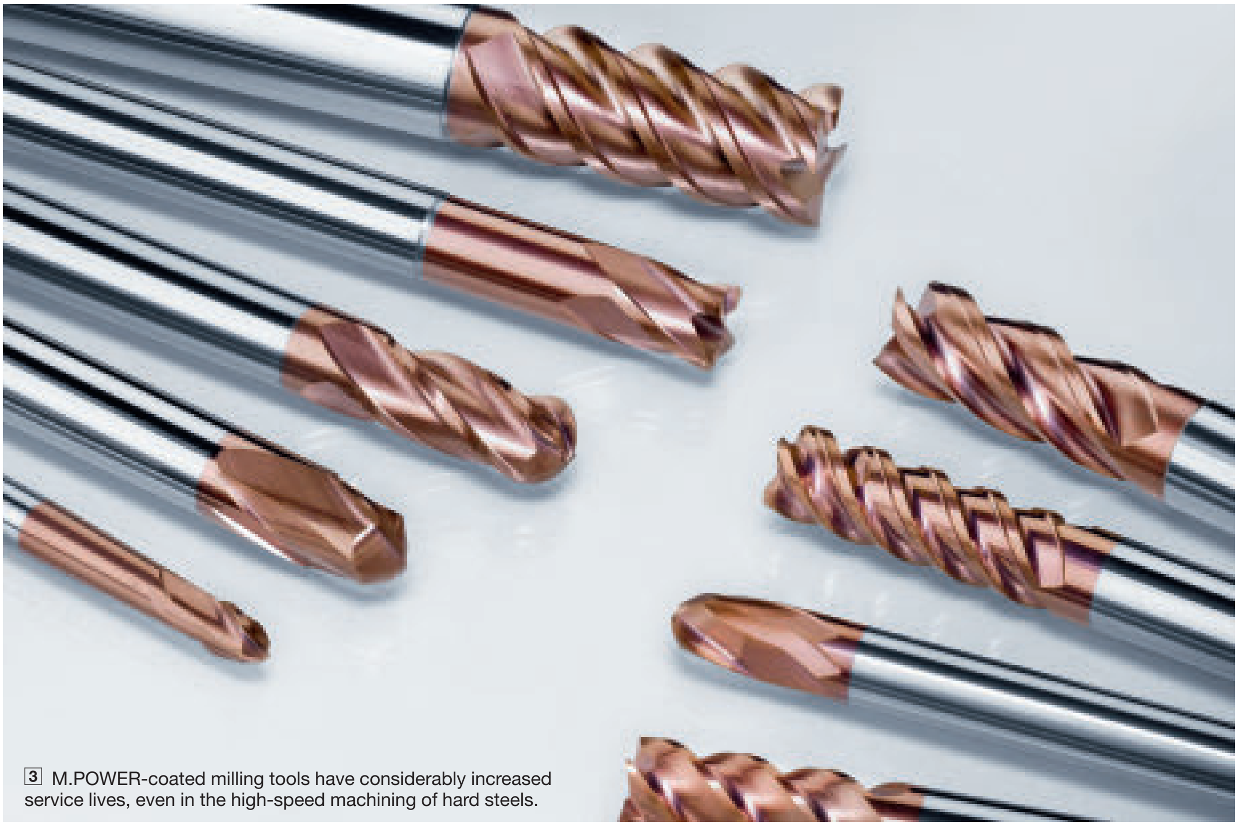
The first coating developments on a HI3-basis show outstanding results in the machining of titanium, in the processing of stainless steels, and with thread-cutting tools. Examples are the new, SiBX-based coatings with increased oxidation stability and VXN-based (vanadium-nitrogen) coatings with improved coefficients of friction at high temperatures.

2 The METAPLAS.DOMINO coating system from Sulzer features the highly efficient, patented, AEGD (arc-enhanced glow discharge) plasma-cleaning process. This additional cleaning step considerably improves the adhesion of the coating to the substrate.

Powerful thanks to M.POWER

Titanium-silicon-based (TiSi) M.POWER coatings (Figure 3) provide outstanding results as all-rounders. These coatings can be used for very hard steels (up to 65 HRC Rockwell core hardness) with a variable proportion of carbide as well as for medium-hard steels (40 HRC Rockwell core hardness). The layer design is similarly adapted in order to meet the diverse range of application areas. As a result, the surfaces are equipped for the machining of everything from high- and low-alloy steels up to hardened materials and titanium.

In short- and long-term tests, M.POWER-coated copy mills showed service lives that were almost doubled due to reduced cutting-edge wear and enhanced surface quality. Further tests carried out in the fine-finish machining operation (on flat workpieces with a Rockwell-hardness of 44 HRC) made it clear that a service life that is almost three times as long and a tenfold reduction in roughness can be achieved with M.POWER-coated tools (see infobox on page 15). The subsequent polishing



3 M.POWER-coated milling tools have considerably increased service lives, even in the high-speed machining of hard steels.

of the surface could be minimized. These are just a few examples from well-known tool and automobile manufacturers who already rely on this coating. The M.POWER family impressively underlines its potential in applications in which high cutting speeds, high temperatures at the cutting edge, and high metal removal rates are required.

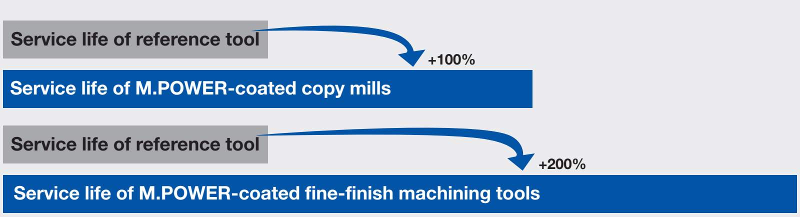
With Sulzer as partner, customers can increase the efficiency of tools throughout their complete life cycle.

For additional PVD coatings (and, in particular, for microalloyed coatings), Sulzer also carries out research on optimized surface solutions in close cooperation with machining companies. Close cooperation with the customer is important in order to be able to move ahead with innovations. In this way, potential improvements in productivity, in the use of tools, in quality, and, last but not least, in the interplay between material, coating, and application can be realized and utilized. Through expert partners like Sulzer, customers can increase the efficiency of machining tools throughout their complete life cycle.

What is M.POWER?

The PVD-coating M.POWER of Sulzer has an innovative microalloyed layer structure and is especially suited for high-performance machining. The M.POWER coating has the following specifications:

- Material: TiSiXN (titanium silicon nitride)
- Possible structures: mono, multi, nano
- Coating thickness: 1-3 µm
- Hardness: 3600 HV (Vickers hardness)
- Max. application temperature: 1150°C



More information: www.sulzer.com/MPowerCoating

Annette Norin
Sulzer Metaplas GmbH
Am Böttcherberg 30-38
51427 Bergisch Gladbach
Germany
Phone +49 2204 299 262
annette.norin@sulzer.com

Georg Erkens
Sulzer Metaplas GmbH
Am Böttcherberg 30-38
51427 Bergisch Gladbach
Germany
Phone +49 2204 299 354
georg.erkens@sulzer.com