Solutions for machining industry

In metal processing, surface solutions such as PVD coatings (physical vapour deposition) improve tools so much that customers can benefit from enormous economic advantages. The article details the advantages of standard coatings and suggests the various ways by which impressive results can be achieved if all the factors are coordinated with one another, from the starting material up to the post treatment.

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 industrialised 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, Oerlikon Balzers has been developing tailor-made system solutions for decades to make tools more resistant, more productive, and longer lasting. The special feature of this holistic approach is the consideration and streamlining of all the influencing factors. Starting from the application-specific requirements, the company finds the best-possible combination of pre and post treatment of the tool surface coating material, layer architecture, system technology with which the coating will be applied.

Targeted pre and post treatments

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 post treatment as well as the coating must be adapted to the application. There are various pre-treatment 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 post treatment (edge preparation, surface treatment, and structuring) also plays a decisive role, in particular, in

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

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 post treatment of tools can be on productivity. For example, performance gains of more than 100% in gear-cutting tools can be achieved through specific preparations.

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. 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.

Tailor-made coatings

Aluminium-based coatings, such as Oerlikon Balzers' BALINIT LATUMA, the aluminium chromium nitride based BALINIT ALCRONA PRO or the nanolayered BALINIT PERTURA, are often used in the machining industry. In these aluminium-based coatings, a thin but dense aluminium 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 aluminium content and the layer morphology. The resistance to oxidation, for example, can be improved through an increased aluminium content, nano-structuring, or micro alloying (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. Today, several individual layers with different chemical compositions can be combined to achieve customised properties. This trend will increase even more in the future, in particular, through new system and process technologies.

Coating technology for the future

Nevertheless, innovation in tool coatings is not limited to coating design and chemistry. It also comes with the industrialisation of ground-breaking deposition technologies such as the S3p technology, which combines the advantages of arc evaporation and sputtering.

In arc evaporation, a small spot of a high electrical current moves on the surface of a target. The material immediately melts and the metal vapour condenses on the work piece. Because of the explosive nature of the process, metal droplets are formed, which may cause a rough surface on the coating surface. Reactive gas can be introduced to form compounds.

Sputtering, on the other hand, is a process whereby atoms are ejected from a solid target material due to bombardment of the target by energetic particles. In thin-film coating, this is achieved by accelerating Argon ions towards a solid target where they knock out metal atoms which are collected at the work piece. Compounds such as metal nitrides are formed by introducing gas in the vacuum chamber.

Developed by Oerlikon Balzers, the S3p technology succeeds in combining the advantages of both technologies in an industrial solution: high ionisation without droplets, smooth coating surface, very high coating density and hardness; and excellent adhesion. Its unique process allows to customise coatings in such a way that they precisely fulfil the requirements of the respective application. The coatings based on the S3p technology, are marketed under the BALIQ coating brand. □

Courtesy: Oerlikon Balzers

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