AlCrN-Based Hard Coatings on Modern Carbide Tools

The refinement of coatings is not just a response to requirements imposed by manufacturing technologies. It also delivers decisive advances with respect to cost-effectiveness and manufacturing reliability.

By Sergio Lopez
2003 marked the birth of a totally new coating generation based on aluminum chromium nitride. It allowed the Oerlikon Balzers research team to open up new dimensions in coating performance. In comparison with TiAlN-based coatings, the AlCrN generation exhibited improvements of all key coating properties such as hot hardness, oxidation resistance, and resistance to abrasive wear. It delivered remarkable results in all typical machining industry cutting speed ranges. The products developed by Oerlikon Balzers, especially BALINIT® ALCRONA, have meanwhile established themselves on a global scale as the benchmark for cost-effective production in cutting applications. Systematic refinements have now kicked off the next big step toward enhanced application characteristics.

The evaluations of a major tool manufacturer confirm the enormous progress made in this domain since the TiN coatings developed by Oerlikon Balzers were introduced. The ongoing development of new and more durable coating systems, combined with improvements and modifications materials and tool geometries, made it possible to boost the material removal rate in roughing by a factor of 15. The norm with TiN-coated HSS mills was 7.5 cm³/min, but today, using cemented carbide mills AlCrN-coated with BALINIT® ALCRONA, it is 120 cm³/min.

In the machining industry, the reduction of tool costs and service life extensions are highly significant. An increase of the number of regrinding and recoating cycles of expensive cemented carbide tools is also one of the industry’s requirements.

The latest-generation AlCrN-based coatings are the right response to these expectations. BALINIT®-coated tools have the following convincing features:

- Excellent service lives at lower cutting speeds
- High process reliability
- Stripping and recoating without performance degradations.

In cooperation with leading international research institutes, Oerlikon Balzers was able to gain an in-depth understanding of the correlations between coating properties and targeted application characteristics. Using the latest analysis methods, the staff members of the Christian Doppler laboratory for “Advanced Hard Coatings” decoded the secrets of doping elements for AlCrN-based hard coatings.

The addition of a few atoms, for instance of the yttrium, silicon, boron, or vanadium groups, produces nanocrystalline coating structures, so-called nanocomposite coatings. This is of decisive importance to the development engineers at Oerlikon Balzers.

According to a general rule of thumb, a significant reduction of costs in mechanical machining can only be achieved by increasing the performance of the deployed tools. This is illustrated by the following numbers:

- A 50% increase in service life reduces manufacturing costs by 1%.
- If tool costs are reduced by 30%, this also results in a 1% reduction of manufacturing costs.
- A 20% increase of cutting parameters cuts manufacturing costs by 15%.

Consistently, tenacity pays off for the development engineers at Oerlikon Balzers. They created several aluminum chromium nitride-based coatings for tools used in cutting and forming applications.

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significance for the mechanical and thermal properties of hard coatings. The addition of a small amount of boron, for example, increases hardness by about 25%, thus improving resistance to abrasive wear.

Many scientific reports focus on hardness values at room temperature. This leaves highly-stressed tools unimpressed. The coating properties under service conditions are what count. In the refinement of AlCrN-based coatings, great emphasis was therefore placed on improving hot hardness. With a suitable coating design approach and the right selection of doping elements, it proved possible to achieve a 50% gain in hardness at service temperature levels.

AlCrN-based hard coatings on modern cemented carbide tools exhibit excellent results in dry machining; longer tool life spans compared with emulsion machining are the rule rather than the exception.

Oxidation resistance and hot hardness are decisive when machining with emulsions, but so is thermal shock.
resistance. The coated tool is exposed to high temperatures when engaged in the stock, and emulsion cooling results in considerable temperature fluctuations that stress the cemented carbide and the coating. In simulations and numerous real-world machining tests, the researchers at Oerlikon Balzers were able to demonstrate that an optimized residual stress profile in the coating and an enhanced etching process produce decisive advantages. Thus, high material removal rates can be attained with a high level of reproductability.

WHAT ARE THE FEATURES OF AICrN COATINGS?

To an unprecedented degree, AICrN coating systems withstand the extraordinary stresses that occur in HSC and HPC machining applications.

With the new coatings, Oerlikon Balzers achieved two important goals: Building on the BALINIT® ALCRONA coating, the company’s engineers succeeded in developing an even tougher all-round coating with outstanding wear resistance, oxidation resistance, and hot hardness. They also designed a further coating that delivers perceptible productivity gains in milling.

BALINIT® ALCRONA PRO has the same chemical composition as BALINIT® ALCRONA. However, thanks to optimized process parameters as well as coating structure modifications, it was possible to significantly improve the residual stress profile and the thermal shock resistance of the coating.

BALINIT® ALCRONA PRO has not only pushed the performance limits of cutting tools to a new level. Thanks to tangibly improved protection against cold welding, abrasive wear, and thermal stresses, tools used in punching and forming as well as aluminium pressure die-casting moulds also exhibit considerably longer service lives, resulting in high-quality work.