Tech Now

PLASMA SURFACE TREATMENT TECHNOLOGY ENSURES SUCCESS LAYER BY LAYER

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New methods emerging today pave the way for applications that were unknown a few years ago. Today, there is hardly any industry that does without plasma surface treatment technology.

By Nikolaus Fecht

It boasts an excellent environmental footprint and is extremely versatile - plasma surface treatment technology. It not only reduces wear and tear, but also prevents corrosion and reduces the friction of surfaces. This leads to a significant increase in the performance of machines and their components and ensures optimal tempering of piston rings and other engine components. The versatility of plasma surface treatment technology never ceases to amaze even long-standing coating specialists. Leading companies in the industry report how they achieve the properties and performance in a wide range of areas through targeted pre-treatment and after-treatment during coating. “Plasma coating technology is absolutely indispensable today for innovative mechanical engineering,” says Dr. Georg Erkens, Managing Director of Surcoatec Deutschland GmbH from Düren and spokesman for the VDMA Industrial Plasma Surface Technology (IPO) working group.

Fundamental for mechanical engineering

Erkens considers this modern surface treatment technology in mechanical engineering to be as indispensable as semiconductors are for the IT industry. Its importance is evident when looking at the variety of industries and applications in which it is used. Plasma coatings can be found everywhere - in aviation, process engineering, automotive engineering and particularly in precision tools. “The primary goal is to reduce and avoid the loss factors of friction and wear and tear by changing the interface properties,” says Erkens. For the specialist from Düren, industrial plasma coating technology is a service offering that allows for differentiation inn increasingly competitive environment.

System solutions are gaining momentum

“With the ever-increasing demands on interfaces, system solutions are coming into focus more and more,” emphasizes Erkens. “Up to now, the high-performance thin films have often been used for material repair, but solutions have recently come into focus that consider a coated component to be a composite.” Developments are currently going in the direction of multi-purpose composite systems. The performance of the system consisting of the component and the layer all depends on the optimized usage data. “Thin films are essential for a wide range of high-performance applications and a key part of the value chain. They are the basis for long service life, operational reliability, performance and increased efficiency.

They prolong operational cycles and reduce unproductive and costly idle times,” explains the expert. “The property profiles of plasma layers are very diverse. In the production chain of food and pharmaceuticals, these thin films reduce wear, friction and adhesion and thus serve as a biocompatible, food-safe and chemically inert barrier between the processing and conveyed material on the one hand and the natural component surface on the other.”

The performance of a thin film system heavily depends on various factors such as macro and microgeometry, surface structure and operating conditions. “The combination of surface microstructuring and plasma coating makes it possible to operate the respective components at their performance limits - and sometimes even beyond that,” states Erkens. “Simply put: Without plasma coating, many applications cannot work at all. But

only in combination with a microstructured surface can users properly utilize the full potential of an excellent layer. It is precisely this holistic, systemic approach that we are pursuing!"

The analysis of the finishing concept of "preparation - coating - finishing" allows for a significant increase in performance, without having to fine-tune the coating and coating process. The expert predicts a future in which both coating and surface structuring are taken as structural elements in the optimum design of coated composite components. In the future, coating will be a fixed part of the component, i.e. the structural composite solution, and not just a vehicle for the repair of the material and the material surface. Erkens: "In the future, it will not only be about developing new layer materials and technologies, but also adopting existing solutions in newly designed composite systems and re-evaluating them from a technical perspective."

New possibilities for designers

Further developments fostered by new innovative methods such as 3D printing technology (additive manufacturing) is also very exciting for Erkens, as they enable completely new design possibilities for coating-compatible composite components. Erkens: "Additive methods will simplify coating-compatible design and manufacture."

Eltropuls Anlagenbau GmbH from Baesweiler near Aachen has long-standing experience in the field of heat treatment with plasma technology. The family business is primarily concerned with plasma diffusion, in which metallic workpieces are "inoculated" with nitrogen and carbon. In scientific terms, these processes are referred to as nitriding and nitrocarburizing. "Plasma nitriding, in particular, is now a widespread method that is used in an increasing number of new applications. By simplifying the process, our goal is to ensure a wider distribution," says Mark Strämke, Managing Director of Eltropuls.

The graduate engineer still encounters general reservations concerning this technology. For this reason, he not only tries to lure potential users with the higher quality but also with the environmental footprint of plasma technology, as it requires only very little process gas during diffusing and coating. "The trend towards higher efficiency and more environmentally friendly methods is certainly helpful in this," asserts Strämke.

Nitriding is a combination of diffusion and coating. The area diffused by plasma (maximum penetration depth: 1 millimeter) serves as a support layer for a ceramic nitriding layer, which is only a few thousandths of a millimeter thick. It is formed by combining nitrogen with the iron.

Good for hybrid constructions

The most crucial advantage of plasma technology is that it can be used to create hybrid constructions in mechanical engineering. "In contrast to conventional technology, plasma processes can be used to selectively treat components; the weldability and machinability is therefore ensured," says the Managing Director. "In this way, it is possible to create welded hybrid constructions from deep-drawn sheet metal parts and machined gear wheels that are lighter and more cost-effective."

Given that the key values can be adapted very precisely to the respective requirements, this method allows for the production of components with optimally adjusted wear or corrosion protection and optimum fatigue strength. Thanks to the option of partial treatment, it is also possible to subsequently process non-treated areas of a component mechanically. Strämke is convinced: "Finished components are usually plasma-nitrided because this process only results in minimum component distortion and deformation. Conventional heat treatment, however, often involves additional hard machining in order to achieve the finished size."

Alternative to hard chrome plating

Plasma-nitriding is also becoming increasingly popular in light of the ban on chromium (VI) corrosion and wear-resistant coatings, which takes effect in the EU as of September 2017. This ban will apply in particular to manufacturers of heavy-duty metal components. "We have customers from the offshore sector who use our process to coat large hydraulic cylinders," says the Managing Director. "Our plasma-nitriding process successfully replaces the previous hard chromium plating." The process has not only proven its worth in the offshore sector, but also with chassis components.

Thomas Müller, Member of the Executive Board at Rübig GmbH & Co KG, Wels (Austria), addresses another aspect: "Increasing the energy efficiency of machines and their processes is becoming more and more important. This means that low-friction and corrosion-resistant layers are increasingly required." But the fatigue strength and corrosion resistance of a component can also be positively influenced in combination

with diffusion processes (e.g. plasma-nitriding). The general trend points towards custom layer design, which can only be achieved by an accurate and early analysis of the customer's goals. This change towards a system approach - surface engineering - is also reflected in the process. Today, more in-depth task analyses are increasingly commonplace.

Conventional mechanical engineering uses Rübig systems for coating all kinds of components, ranging from machine tool parts to aluminum die-casting and injection molds. Since this is not a line of sight process, there are only few constraints on geometries. "The process can be used wherever machines or individual components are used around the clock and where long service life and cost-efficient solutions are required," explains Müller.

Trend towards conductive protective layers

Rübig primarily relies on plasma-assisted CVD (chemical vapor deposition) systems, which are mainly used for coating in large-scale production. "With our technology, corrosion-resistant layers with a thickness of up to 50 micrometers can be applied," says Müller. "This layer thickness is very exceptional." Because of their robustness, these layers that also are known by the abbreviation DLC (diamond-like carbon) among specialists. The trend towards electromobility gave rise to a conductive version of this DLC layer, which is also being developed at Rübig's plants in Wels. Likewise, Rübig will benefit from the EU-wide ban on chromium (VI) protective coatings effective from September onwards, as the company has been offering diffusion and oxidation processes as an alternative for a long time. And the company has been pursuing another current trend for around 20 years - Rübig is building hybrid systems that allow for the thermochemical treatment and coating of components all in one process.

Despite these advantages, many users still shy away from surface treatment technology due to the investment needed for implementing the technology. But the argument of higher costs can no longer be maintained. In terms of life cycle costs, plasma technology is no more expensive than conventional methods for heat treatment or coating in single-item or large-scale production. And it is now also suitable for very complex components, according to Müller. Users should therefore not miss out on the opportunities of efficient plasma coating. "These arguments paved the way for our entry into large-scale production years ago," says the Managing Director of the medium-sized company.

Increased performance thanks to coating

Oerlikon Balzers Coating Germany GmbH from Bingen specializes on the coating of tools and components for customers from various industries. "Today's performance requirements, such as for cutting tools, can no longer be achieved without coatings," says Managing Director Hendrik Alfter. "They are now indispensable for high-level requirements." And for good reasons, as coatings can significantly increase the service life of a tool, i.e. its working time until wear-induced replacement is needed. Compared to conventional products on the market and depending on the field of application, the service life is increased by 30 percent or more. "One of our latest PVD coatings for cutting tools even doubles the service life in some applications," says Alfter. "This is primarily the case at the highest cutting speeds. Our customers can also significantly increase their machine capacity utilization and thus their productivity."

According to the expert, the increased demand for special coatings in small batch sizes, especially since the crisis in 2010 is another important trend. "Small batch sizes are now very much in demand and this trend is continuing unabated," observes the Managing Director. "Customers also attach great importance to delivery reliability and speed, as the coated tools are to be produced very quickly or just in time."

For most users, the discussion around the high costs for the coating also seems to be passé. "The closer and more trusting collaboration between our customers' buyers and technicians seems to actually bear fruit," says Alfter. "This shows once again that value is increasingly placed on the price-performance ratio. Hardly anyone is looking for purely cheap products today."

Close network with tool manufacturers

In order to offer users a high level of added value, notable tool manufacturers are calling on the services of the surface specialist Oerlikon Balzers early on in their development of new tools. They often test Oerlikon Balzers' coatings in the development phase in order to optimally adapt their tools and their geometries. "Today, the innovation steps in the world of tools are often less spectacular," explains the Managing Director. "This is why it is very helpful when tool manufacturers, users and coaters work together from an early stage. This applies to the development of both tools and coatings."

A new coating solution that continues to amaze the experts can only be created in this way - through collaboration on all sides. ■

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