Atmospheric Plasma Coating – Subsequent Integration Into The Process Chain

A supplier to the automotive industry was faced with the challenge of retrofitting an anticorrosive treatment for an aluminium part into an existing process chain. A special coating process with atmospheric-pressure plasma for this purpose fulfils all requirements with regard to quality, feasibility of integration and costs.

Photo: Plasmatreat
Fig 1: No costly vacuum chamber needed: The new PlasmaPlus technology applies nanothin coatings to material surfaces under atmospheric pressure

Plasma coating is a process that until recently could only be carried out in a vacuum. Working in close co-operation with the Fraunhofer Research Institute IFAM, Bremen, the German Plasmatreat GmbH, has developed and patented a new process by the name of PlasmaPlus that made it possible for the first time to apply nanothin coatings to material surfaces under normal air conditions. The plasma coating process is applicable for automated, large scale industrial applications. It is based on the manufacturers technology "Openair-Plasma", which today is used worldwide in the most varied industries for the microfine cleaning and high activation of material surfaces. To produce a coating, an organic silicon compound is added to the atmospheric-pressure plasma used here. As a result of high-energy excitation in the plasma, this compound is fragmented and deposits out on a surface as a vitreous layer. The chemical composition can be modified depending on the specific application in order to achieve the best results for different materials.

Plasma coating in the car sector

At TRW Automotive, a global supplier for vehicle safety systems, engine pump housings for steering units have been coated using Openair-PlasmaPlus technology since 2007. Compared with the process previously used, in which a fluoropolymer-based anti-corrosive agent was applied manually to the adhesive seam from the outside after bonding, significantly improved tightness could be achieved with the plasma polymer layer. In an exposure test, the time taken until 'penetration' occurred (appearance of the first signs of corrosion inside the housing) increased by approx. 50% to over 750 hours (Fig. 2).

Coating is carried out in-line and ensures the highest possible protection against the ingress of moisture. TRW Automotive subjects on top the groove surfaces of the engine pump housings to microfine cleaning and activation with the Openair plasma technique prior to the PlasmaPlus coating (Fig. 3). Even microscopically small leaks resulting from corrosion can lead to short-circuiting and the loss of power steering. Coating with an atmospheric-pressure plasma plays a key role here.

Subsequent integration into the process chain

Once all the quality requirements for new developments are known, implementation is possible using the corresponding influencing factors, such as design, process chain planning, corrosion protection measures etc., using well-established technical solutions.

It is significantly more difficult if customer requirements come to light in the later stages of projects when their overall process chains are already in place. In such cases, well-established technical solutions can often no longer be integrated, or only so if massive changes are made, with correspondingly high investment costs. Furthermore, changes in production processes that involve alterations to the plant result in production outages.

SWAAT-Test	Test duration [hours]			
	50	250	500	750
Without corrosion protection	leak-free	leaky	leaky	leaky
Anticorrosion grease sprayed on	leak-free	leak-free	leak-free	leaky
Coating with PlasmaPlus® plasma	leak-free	leak-free	leak-free	leak-free

Table: Plasmatreat
Fig 2: Leakage test after salt spray test (SWAAT test): green: housing shows no leaks; red: housing is leaking (corrosion on flange with penetration to inside)

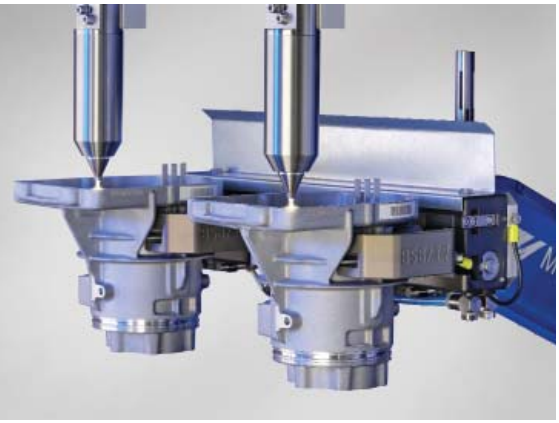

Photo: Plasmatreat
Fig 3: TRW Automotive subjects the groove surfaces of engine pump housings to microfine cleaning and activation with an Openair plasma prior to PlasmaPlus coating

TRW was faced with such a challenge in 2006 following new requirements from a customer and well-known carmaker. The possible ways of making an existing TRW Generation C motor pump unit with a die-cast aluminium housing to be more resistant to environmental influences were limited to the following options: upgrading the material, anodising, passivation, or low-pressure or atmospheric-pressure plasma coating.

Upgrading the material, i.e. changing the aluminium alloy quality, is a major change because typically it also results in other effects such as a loss of tensile strength. This would result in having to conduct a completely new product validation resulting in very large amounts of effort and very high costs. Likewise with anodising: the process-related film formation on the surface leads to appreciable increases in the dimensions, and will thus have an effect on the fit. Furthermore, with the lamellar structure there are also risks with respect to contamination of the hydraulic steering system, as well as critical changes to the coefficient of friction of highly stressed screwed joints. Thus anodising would also necessitate comprehensive product validation.

Passivation is a good form of corrosion protection and has the added benefit that the necessary thickness of the layer to be formed is not significant. However, for TRW Automotive the heat resistance of the layer was inadequate for the applications and internal production processes and this approach could thus not be adopted.

The possibility of using low-pressure plasma coating presupposed a willingness to invest in the necessary autoclaves. If there is a large capacity requirement, and depending on the component geometry, the investment costs can be correspondingly high.

All three of the possibilities considered thus far have one thing in common: they are very costly and would have to be integrated into the process chain in such a way that quality would be in the hands of global suppliers. Carrying out quality control on finished components that are in the as-supplied condition is extremely complex and thereby reduces process reliability considerably.

Compared to other corrosion protection processes the atmospheric-pressure PlasmaPlus coating offered decisive benefits. An integration in TRW's final assembly process was possible with little effort and without disruptions to production. At the same time, the process offered an ideal opportunity for integration in TRW Automotive's own quality assurance processes.
Due to the possibility of applying plasma coatings selectively, critical areas remain unaffected. New validations are thus not necessary and the investment and maintenance costs are also low. The small space required, low maintenance needs and short cycle times were additional criteria for installing the Plasmatreat process at TRW Automotive. According to the automotive supplier, the use of this coating technology for die-cast aluminium housings has created new standards of quality.

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