

ATMOSPHERIC-PRESSURE PLASMA ENSURES CORROSION RESISTANCE

Nanometer thick coatings in series production

Whether for corrosion protection, as an adhesion agent prior to bonding, or for ease of surface cleaning – a newly developed method allows for selective coating of metal surfaces with different functionalised layers based on atmospheric-pressure plasma technology.

Higher requirements on the corrosion resistance of, for example, bonded metallic components demand for innovative solutions. One of the global players from the subcontractors to the automotive industry was faced with the challenge of retrofitting an enhanced anticorrosive treatment for an aluminium component into an existing production line. The use of the atmospheric-pressure plasma coating process makes this possible.

Nanocoating at atmospheric pressure

Until just recently plasma polymerisation was a process that could only be carried out in vacuum. However, in close collaboration with the Fraunhofer IFAM Institute, Plasmatrete developed and patented a new technology allowing for a nanometer thick coating of material surfaces at atmospheric pressure (Figure 1). It is hardly three years ago that this technique found its way into an industrial application for the very first time. A special feature of this process is its high cost efficiency, since in contrast with low-pressure techniques, it does not require a low-pressure chamber. The principle of this method is based on the fact that an organosilicon compound is admixed with the atmospheric-pressure



Figure 1: What was previously only achievable in the vacuum chamber is now possible in-line under normal atmospheric pressure: The functional coating of aluminium components.

plasma to produce a layer. Due to the high-energy excitation in the plasma, this compound is fragmented and deposited as a vitreous layer on the surface to be treated. The chemical composition can be varied according to the type of application to achieve the best possible results on the various materials.

Corrosion protection of aluminium

Using this system, for example, as a corrosion protection for aluminium surfaces brings about a number of advantages: In contrast with other coating techniques, it is suited for in-line use on the one hand and for the solution of selective coating tasks on the other. The anti-corrosive effect is particularly marked in aluminium alloys. The layer is capable of protecting aluminium against direct salt spray (DIN 50021) for several days without the visual appearance of the metal being affected. By means of plasma from a jet system, corrosion protection is applied without contact with the surface of the aluminium (Figure 2). Since the new method operates under normal atmospheric pressure, it does not require a vacuum to deposit a layer.

Another special feature of the process is its great flexibility: In particular the film thickness and the speed of the process can be matched in line with requirements to the anticorrosive effect needed (Figure 3).

Typical processing speeds vary from 5 to 30 m/min. Directly after application of the coating, the component can be processed further. The coating affords not only high resistance to corrosion but also a stable, peel-resistant substrate for

adhesives and sealants. The process is furthermore very environmentally friendly and there is no need for disposal or treatment of chemicals.

Plasma coating in the automotive sector

The atmospheric plasma coating process described here was used for the first time in an industrial application by TRW Automotive, a manufacturer of various types of vehicle safety systems. The task was to reliably protect a motor pump housing for a power-assisted steering system against corrosion. This is achieved by selective in-line coating of the bonded joints on the metallic component surfaces with atmospheric-pressure plasma.

The coating ensures greatest possible protection against penetration of moisture. In this way it can be safely avoided that microscopically small leaks occur causing corrosion and resulting in a short-circuit and failure of the power-assisted steering system. Coating with atmospheric-pressure plasma therefore assumes a key role here (Table).

Subsequent integration into the process chain

In new developments when all quality requirements are known, implementation with the aid of appropriate influencing factors, such as design, process chain planning or anticorrosion measures, etc. is achievable using commonly available technical solutions. Incomparably more difficult are subsequently arising customer demands in projects already under way with existing global process chains. In such cases commonly available technical solutions are frequently no longer capable of integration or this can only be done by making enormous changes in association with high investment costs. Moreover, changes in production processes including reconstruction measures give rise to downtimes in production. Nevertheless, due to new demands from a customer and

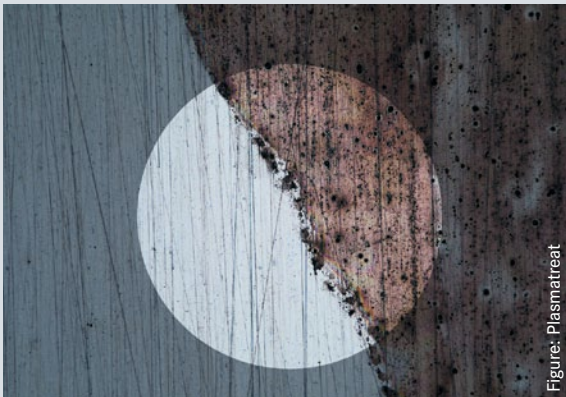


Figure: Plasmamatreat

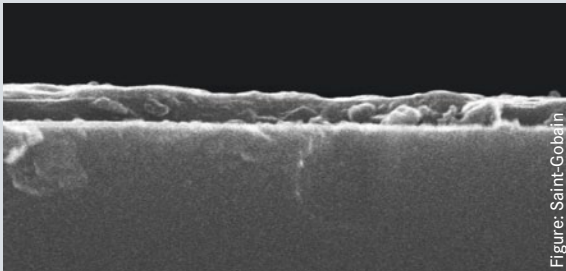


Figure: Saint-Gobain

SWAAT test	Test duration [hours]			
	50	250	500	750
without corrosion protection	sealed	leaky	leaky	leaky
Anticorrosive grease sprayed on	sealed	sealed	sealed	leaky
Coating with atmospheric-pressure plasma	sealed	sealed	sealed	sealed

Table: Leak-proofness check by the salt spray (SWAAT) test:
 Green: Housing shows no leaks
 Red: Housing is leaky (corrosion on flange with breakthrough towards the inside)

renowned automotive manufacturer, TRW decided in 2006 to take the challenge. The possibilities for protecting a current TRW generation C motor pump unit having an aluminium pressure die-cast housing against environmental effects were limited to the following options: improvement of the material, anodisation, passivation or plasma coating at low or atmospheric pressure.

Improving the material, i.e. interfering with the quality of the aluminium material, is a dramatic change since this is also typically accompanied by other effects, such as a decrease in tensile strength. This would have entailed completely new product validation involving great effort and costs.

Much the same applies to the anodisation. The formation of the coating on the surface on which the principle of this method is based results in significant changes in dimensions and therefore in an impact on the fitting system. The lamellar structure also carries risks with regard to contamination of the hydraulic steering system and critical changes in friction at highly stressed screwed joints. Anodisation, therefore, would also make extensive product validation necessary.

Passivation affords good protection against corrosion and has the advantage that no layer of appreciable thickness is formed. However, its heat resistance was not sufficient for the applications and

Cost efficiency comparison

Surface pretreatment and coating with atmospheric-pressure plasma compared to low-pressure plasma and other methods:

- Compared to low-pressure methods, the atmospheric-pressure plasma technology is far more efficient since the pretreatment process does not require a costly low-pressure chamber and takes place in-line in the production line under normal atmospheric pressure.
- Components treated at low pressure, i.e. in vacuum, are limited in size and number by the constraints of the required chamber. Production processes must be interrupted for pretreatment, and assembly is usually carried out manually.
- The described atmospheric-pressure plasma technology is suitable for robotic and in-line applications without restriction. The system can be very easily integrated into new or already existing production lines. Production rates are increased by a significant multiple and the deployment of manpower is considerably reduced.

- With low-pressure plasma neither cleaning processes for strip-like products, as is the case for coil coating processes, nor large-area pretreatments for bonding processes can be implemented.
- Chemical treatments require consumables and often leave behind residues that are difficult and very expensive to dispose of. The plasma technology completely replaces chemicals in the cleaning process in the majority of cases.
- Mechanical pretreatment methods (scoring) are very difficult to implement reliably and also operate with consumables.
- The described plasma technology is absolutely process safe and has been developed for continuous use in automated production.

The atmospheric-pressure plasma technology, however, is not suited in cases where surfaces are inaccessible to the atmospheric-pressure plasma beam due to complicated geometries or where the production layout is already designed for chamber processes.

internal production processes at TRW so that this method had to be excluded as well.

The possibility of low-pressure plasma finally presumes some readiness to invest in corresponding plant technology. When there is requirement for high capacity and/or complicated component geometries, high investment costs may be necessary.

All three variants considered so far have one thing in common: they are highly cost-intensive and would have to be capable of integration into the process chain in such a way that quality control would lie in the responsibility of global suppliers. Subsequent quality control on finished components ready for delivery is very costly and considerably reduces the reliability of the process (see also the Cost efficiency comparison).

Conclusion

Compared to other corrosion protection methods, the atmospheric-pressure plasma coating process could be inte-

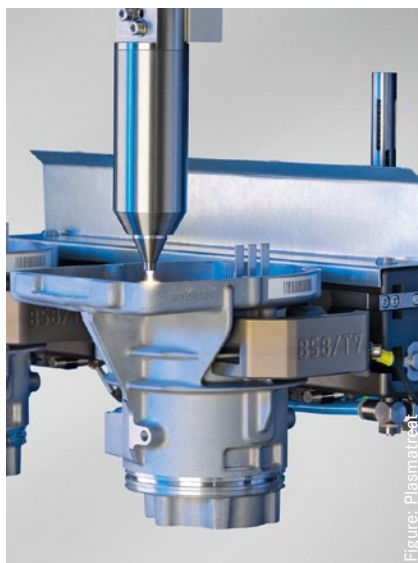


Figure 4: Prior to plasma coating TRW motor pump housings are precleaned with Openair plasma to a microfine level.

grated into TRW's final assembly with little expense and without disturbances in production. At the same time the process could be ideally incorporated into the in-house quality assurance

processes (Figure 4). Due to the possibility of applying plasma coatings selectively, critical areas remain unaffected so that new validations are not necessary. The low investment and maintenance costs are also of advantage. The low requirement for space and maintenance effort together with short cycle times were further criteria for the integration into the here described application. ■

The Author

Inès A. Melamies (im@bluerondo.de) is the owner of the management consultancy firm Blue Rondo International in Bad Honnef, Germany

More information on this topic:
Plasmatreat GmbH,
33803 Steinhagen, Germany
Tel.: +49 (0) 5204 9960-0
mail@plasmatreat.de
www.plasmatreat.com