Adapted version from the German original: JOT 9. 2007



IN-LINE COATING USING ATMOSPHERIC-PRESSURE PLASMA

# Selective corrosion protection for aluminium housings

**A large supplier to the automotive sector has recently started using plasma technology for pre-treating motor pump housings. With the new process the surfaces of metallic components are selectively coated in-line at atmospheric pressure to prevent bond line corrosion.**

Whether the aim is to provide protection against corrosion or to facilitate cleaning of a surface, the PlasmaPlus technology newly developed by Plasmatreat GmbH based in Steinhagen in collaboration with the Fraunhofer IFAM, Bremen, offers an abundance of differently functionalised layers for selective coating. The basis of the new process is the “Openair” atmospheric-pressure plasma technology that is already used throughout the world.

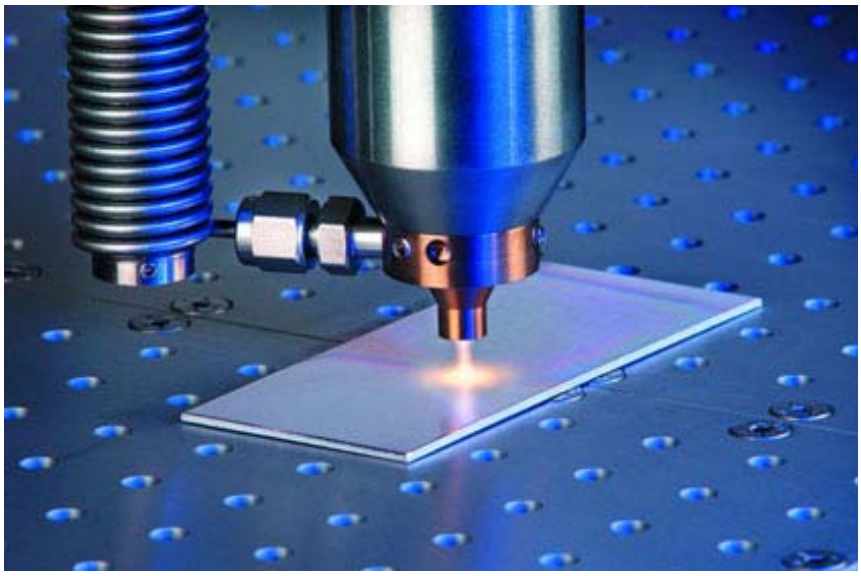

Photo: Plasmatreat
Surfaces can be selectively activated and coated by the system which operates on the jet principle

A large supplier to the automotive sector has been using the technology since earlier this year to protect steering system components against corrosion.

## Glass-like passive layer

To produce a layer an organosilicon compound is admixed with the atmospheric-pressure plasma employed here. Due to the high-energy excitation in the plasma this compound is fragmented and deposited on a surface in the form of a glass-like layer.

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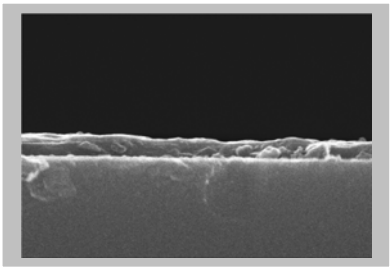
The chemical composition can be varied according to application in order to achieve the best results on different materials (e.g. metal, plastic, glass or ceramics).
To evaluate the film thicknesses SEM (scanning electron microscope) studies are carried out. At a magnification of 50,000 the SE micrographs of coated sample cross-sections reveal a homogeneous layer structure free of pores. This is very important in corrosion protection because it identifies a passive protective layer, i.e. the attack of corrosive media is prevented by a barrier effect. The material in the layer itself is not sacrificed during the corrosion process as would be the case in a galvanised steel surface (active corrosion protection).

## Particularly effective for aluminium alloys

Apart from its use in-line, the great advantages of PlasmaPlus technology with respect to other coating techniques arise especially in selective coating. The anticorrosive action is particularly effective for aluminium alloys. The layer can protect the aluminium for several days against direct salt spray mist (DIN 50021) without the visual appearance of the metal being affected.
To demonstrate the mode of action an aluminium plate (Al 99.5) was partly coated while the rest of the surface remained in the unprotected initial state. After 96 hours exposure to the salt spray test the uncoated aluminium surface proved to be highly corroded (matt surface) while the coated area still exhibited its original lustre. The transition between the corroded and uncorroded region is clearly discernible in the photomicrograph at 100x magnification.



Section through a plasma layer approximately 100 µm thick (SEM at 50,000x magnification)

Under the microscope the region protected by the plasma layer exhibits no sign of corrosion even after direct exposure to the salt spray test for 96 hours

If the plasma coating is to be used for corrosion protection a thick layer (several hundred nanometres) is advisable since this is more resistant to corrosive media such as electrolyte solutions, acids and alkalis. For an adhesive layer just a few nanometres suffice. A thin layer already possesses all the important functional groups with which the adhesive can react and undergo strong bonding.

The very good adhesion of the coating to the base material very effectively prevents any infiltration of the bond line (bond line corrosion). In the case of an adhesively bonded component, such as a motor housing or printed circuit board housing, infiltration is particularly harmful since then power transmission in structural joints is no longer ensured or in the case of housings sealed with sealing adhesive leaks can occur.

## Improved leak-proofing with plasma

At TRW Automotive, world market leader for vehicle safety systems, the motor pump housings for steering units have been coated for the first time since earlier this year by means of Openair PlasmaPlus technology.

Coating is carried out in-line and ensures best possible protection against the penetration of moisture. Even microscopically small leaks arising from corrosion can result in a short circuit and in failure of steering assistance. Coating by means of atmospheric-pressure plasma plays a key role here.

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The parts fed in via a rotary table are first of all subjected by two robots to an identification check by bar code scanner and then checked for dimensional accuracy. The flange surfaces to be bonded are then intensively cleaned by plasma from organic contaminants, for example minute residues of milling and drilling emulsions, so that the organosilicon layer applied afterwards can bond in optimum fashion to the aluminium housing. After a thin coating is applied the housing parts are deposited on the rotary table and can be removed by the operator. In another production sequence the adhesive is metered out and the housing cover is fixed in place. As a result of this process sequence the bonding joint is ideally protected against infiltration and the housing material against corrosive attack in the flange region.

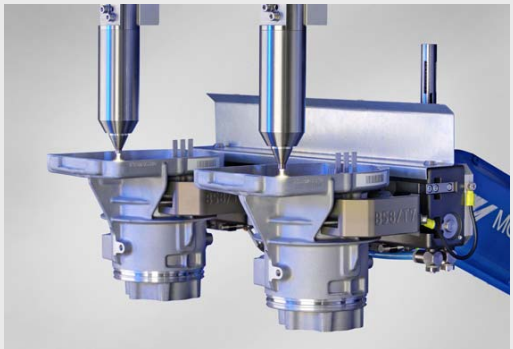
The mechanical, but above all the corrosive stresses to which the part is subjected during its useful life must not result in failure of the adhesive joint as otherwise the electric motor together with the electronics would no longer be protected. These environmental effects are simulated by weathering in the SWAAT test (sea water acetic acid test).

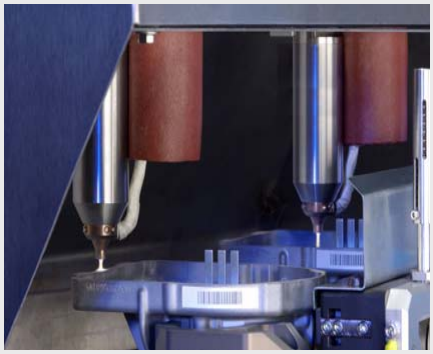
## Plasma coating at atmospheric pressure

Plasma is the name given to matter at a high, unstable energy level. Energy is input via the solid, liquid and gaseous states of matter, always in the form of heat. If by means of electric discharge additional energy is fed into the material excited states of electrons arise. When this happens the electrons can leave their atomic shells and molecular bonds are broken. This results in the formation of free electrons, ions and molecular fragments. The atmospheric-pressure plasma process operating at zero potential (Openair) developed by Plasmatreat made it possible to exploit this fourth state of matter for industrial purposes about ten years ago. Through the development and use of plasma jets this state of matter, scarcely used hitherto in industry, was successfully used for the first time in production processes, even in-line. The systems based on a jet principle operate at atmospheric pressure. With the aid of an electric arc ignited in the jet and the working gas, air, a plasma is generated. The plasma flows at zero potential onto the product to be treated. It contains particles which are sufficiently excited to initiate selective effects on the surface. The jets are operated with air, possibly also with another desired process gas, and at high voltage.

A particular characteristic of the emerging beam of plasma is that it is electrically neutral which greatly extends and simplifies its range of uses. Its intensity is so high that machining speeds of several 100 m/min can be attained. The Openair system is characterised by a threefold action: it activates a surface by selective oxidation processes, discharges it at the same time and brings about ultrafine cleaning and high activation of the surfaces of metals, plastics and glass.

In addition the plasma energy of this system is used for forming coatings. A particular economic feature is that the user can always integrate the jet systems employed in-line, that is directly into new or already existing production lines





Prior to plasma coating the motor housings are very finely pre-cleaned with atmospheric-pressure plasma (left) after which they are coated. For this purpose an organosilicon compound is admixed with the plasma (right). Photos: Plasmatreat

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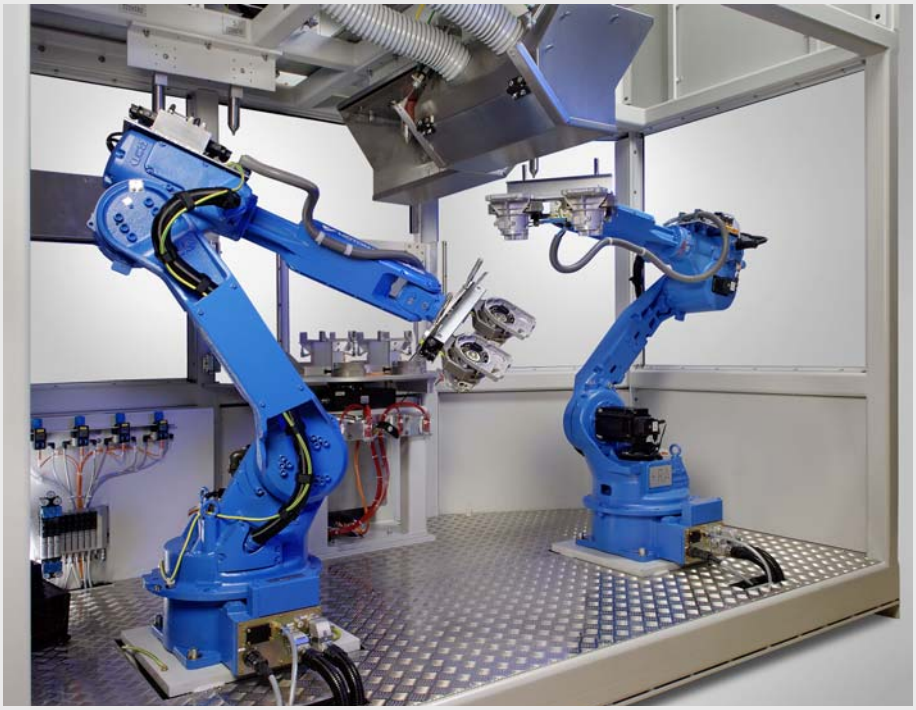

Photo: Plasmatreat
Robot installation for plasma coating motor pump housings for the automotive industry.

| 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 Openair plasma | leak-free | leak-free | leak-free | leak-free |

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

By comparison with the original process in which after bonding an anticorrosion agent based on a fluoropolymer is manually sprayed from the outside onto the bond line, substantially better leak-proofing was achieved with the plasma-polymerised layer. In the weathering tests the duration until "breakthrough", i.e. the appearance of the first signs of corrosion in the interior of the housing, was increased by about 50 % to over 750 hours. Accordingly, coating by the new plasma technology affords not only the optimum preconditions for an enduringly stable adhesive bond but also simultaneously ensures a long service life for the part.

## Uncomplicated handling

The Openair plasma system is capable without restriction of implementation in-line and is compatible with robots. It allows the application of a highly efficient anticorrosive coating or layer of adhesive bonding agent to the most varied substrate materials and so is a versatile tool for cleaning and coating aluminium surfaces.

Due to the small quantities and non-toxicity of the chemicals used in coating the process is highly environmentally friendly. No additional solvents are needed. The removal of coatings prior to a recycling process is not required because they contain no harmful compounds. The coatings can be passed on for recycling together with the substrate material.

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