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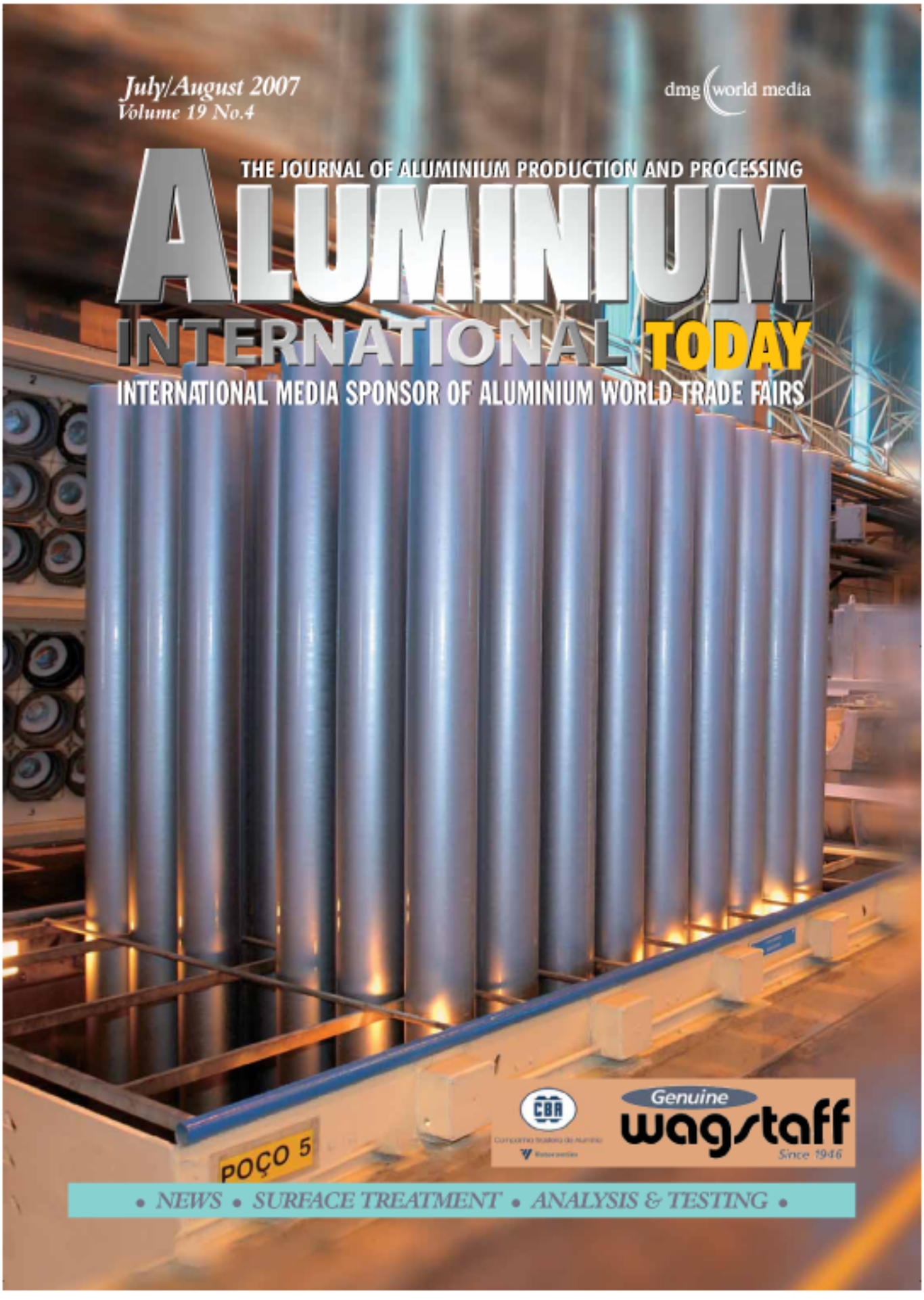


• NEWS • SURFACE TREATMENT • ANALYSIS & TESTING •

SURFACE TREATMENT

Pre-treatment of aluminium with plasma in air

A plasma cleaning process which operates at atmospheric pressure offers great environmental benefits by removing the need for chemical cleaning processes and heat cleaning processes.

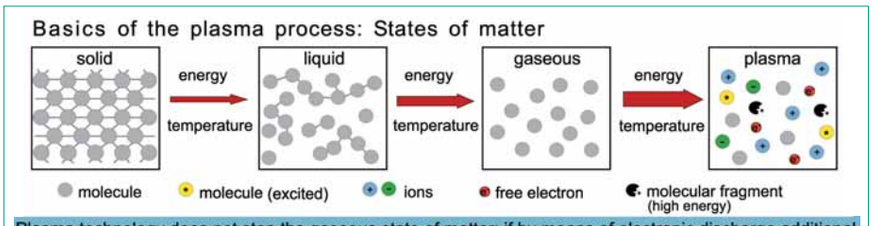
By A Knospe*

Atmospheric-pressure plasma technology is revolutionising the pre-treatment of aluminium and at the same time is demonstrating environmental conservation in exemplary fashion.

Corrosive attack on surfaces, residual contamination due to sheet metal rolling oils and the environmentally harmful and energy-intensive pre-treatment processes used to deal with such situations are among the most common problems in the processing of aluminium.

'*Openair*' plasma technology which takes place at atmospheric-pressure rather than in a vacuum as normally required, has been developed by the German system supplier *Plasmatreat*. This innovative technology brings about ultrafine cleaning, high activation and ultrathin coating of aluminium surfaces and is a substitute for wet-chemical processes.

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 an electric discharge, additional energy can be fed into the material to excite the electrons to higher energy levels. When this happens the electrons can leave their atomic shells and molecular bonds can be broken. This results in the formation of free electrons as well as ions and molecular fragments made up of atoms which have lost electrons. Only the Openair atmospheric-pressure plasma process operating at zero potential made it possible to exploit this 'fourth state' of matter – plasma – for industrial purposes (**Fig 1**). Through the development and use of plasma jets this state is being successfully used for the first time on a production line.



1 States of matter

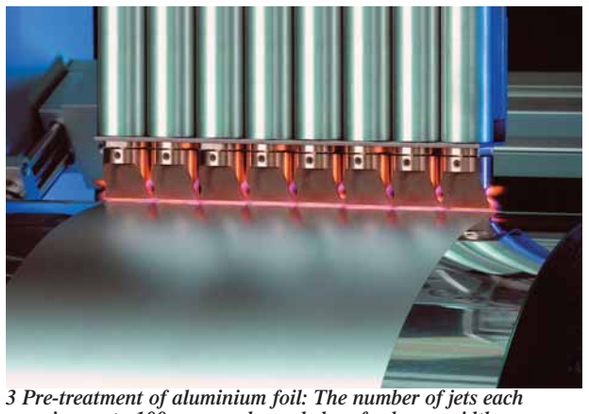
UNCHARGED PLASMA BEAM

The systems based on a jet principle operate at atmospheric pressure. With the aid of an electric arc ignited in the jet and a working gas – air – a plasma is generated. The plasma flows without potential onto the product to be treated. It contains particles which are sufficiently excited to initiate selective effects on the surface (**Fig 2**). The jets operate with air but it is possible to use another process gas if required, and also impart a high voltage. Depending on the geometry of the jets the emerging plasma is effectively spread in an operating range of up to 100mm width using the rotary jet option (**Fig 3**). A particular characteristic of the emerging plasma is that it is electrically neutral which greatly extends and simplifies its range of use. Its intensity is so high that machining speeds of several hundred metres per minute can be attained. The temperature rise experienced is minimal. For example it can be used on polymers where a typical increases in temperature during treatment is just 20°C. The 'Openair' system is characterised by a threefold action:

– it activates a surface by selective oxidation,
– discharges static charges at the same time and
– brings about ultrafine cleaning.

The patented Openair technology owes its international expansion, which has occurred in just a few years, not least to the special feature that the user can always integrate the jet systems employed in-line, that is directly into new or already existing production lines.

2 The electrically neutral plasma beam allows ultrafine cleaning, high activation and extremely thin coating of surfaces.



3 Pre-treatment of aluminium foil: The number of jets each covering up to 100mm, can be scaled up for larger widths

APPLICATIONS

CLEANING AUTOMOTIVE TRIM

Decorative aluminium trim strips on motor cars have grown in importance in recent years. As an appealing design element they now adorn even cars in the lower mid-range. Here visual requirements are distinctly high. Special value is attached to an immaculate glossy finish. Naturally this gloss must withstand routine daily corrosive attacks (water, salt and temperatures) and be able to do this over many years. This degree of protection against corrosion is usually obtained by anodising and subsequently sealing the oxide surface.

However, extreme demands on corrosion protection are likely to arise from new planned washing processes on the assembled car to remove the protective wax coating added to the trim to prevent damage during assembly. These will replace time consuming manual cleaning but require highly alkaline washing solutions (pH 13.5). An outstanding level of corrosion protection is needed to cope with this future washing process. Even after one or two minutes a surface protected only by an anodised oxide layer will be so damaged that the gloss is lost.

To deal with this problem Plasmatreat has developed a coating which protects the gloss during the high alkaline washing process. The coating based on

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organosilicon compounds is applied by robot. It has no effect on visual appearance and provides the surface in daily use with an additional level of protection against corrosion beyond that provided by anodising.

DIECAST ALUMINIUM

Diecast aluminium housings are frequently employed in the automotive industry to protect electronic components such as engine control systems and electric motors against corrosive attack. The weak point is the adhesive joint in the housing which is usually composed of two halves. Depending on environmental conditions this can result in corrosion infiltration of the adhesive joint and hence in the housing losing its airtight seal. The consequence is failure of the electronics.

Plasmatreat in collaboration with the Fraunhofer Institut in Bremen within the framework of AIF Project No12651 N/1 (German Federation of Industrial Research Associations) has developed a coating which greatly slows down corrosive infiltration and is also readily bondable. The film is deposited directly onto the mating groove of the shell half by robot under Openair plasma (**Fig 4**). The adhesive is then applied and the housing assembled. It turns out that the joint in a housing protected in this way is ten times slower in suffering corrosive attack than is the case for an untreated housing (SWATT test). In the next few years housing coated using Openair plasma will be found by the million in the vehicles of European car manufacturers.

4 Coating the groove region of an aluminium housing for electronics

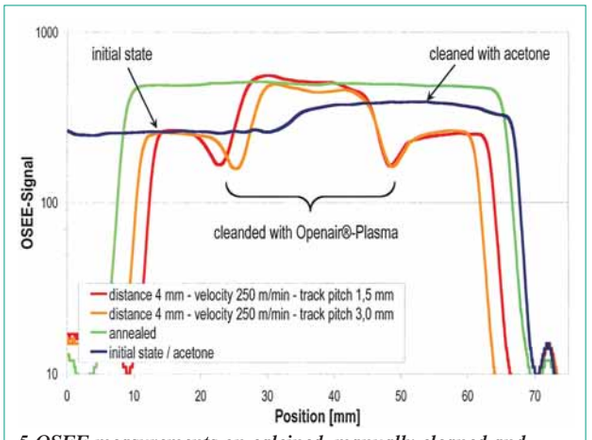
CLEANING OF SHEET

In the rolling process used for foil production, drawing oils are employed which later have to be removed. Since the foils are to be used subsequently in the packaging sector thoroughly effective cleaning must be ensured. The current method is to use the so-called calcining process. In this the foil on the coil is calcined for 72 hours in large kilns. The now hot oil diffuses out, passes over into the gas phase and is drawn off by suction. This process is highly time-consuming and energy-intensive.

Plasmatreat has developed a process that allows efficient in-line removal of the contaminants at speeds of up to 250m/min. For this purpose Openair plasma jets are mounted on a cross-bar in such a way that the metal surface is cleaned on both sides. Examining the cleaned surface with OSEE spectroscopy (Optical Stimulation of Electron Emission) it was possible to demonstrate that plasma cleaning yields results that are as good as those of the calcining process (**Fig 5**). Thus, by using Openair plasma, foils can be cleaned equally well but many times faster and with distinctly lower energy consumption.

COIL COATING

In collaboration with the Swiss company Griesser AG Schweiz and the German research institute Nanocraft, the first industrial application of an in-line plasma cleaning system for aluminium sheet material was implemented. Griesser utilises the method in the coil coating process for producing aluminium roller shutter elements.



5 OSEE measurements on calcined, manually cleaned and plasma-treated aluminium foils

6 A world first: Use of plasma in the coil coating process at Griesser. Large volumes of wet chemicals are rendered superfluous by the plasma treatment

The company had decided to invest in a new plant for coating aluminium laminates which will operate not only much more efficiently, but also avoid any use of chemicals in pre-treatment.

Branko Vasiljevic, Coil Coating Project Leader who has worked for Griesser AG for many years, is enthusiastic about the possibilities of this relatively young Openair plasma technology. His vision to implement a new, environmentally friendly paint shop which will enable cleaning of the aluminium strip in-line and also significantly reduce the floor area required has resulted in the commissioning of the Openair plasma pre-treatment process the first anywhere in the world.

An extensive research project commissioned by Nanocraft finally confirmed his expectations that it would be possible to use atmospheric-pressure plasma in large-scale industrial production and that it would be effective in pre-treatment, ie in cleaning and activating aluminium surfaces in preparation for coil coating. In the trials conventional chemical pre-treatment was used as a reference system. The material and plasma parameters (focusing the plasma, intensity and energy input rate) were optimised and the plasma was shown to be distinctly superior to conventional pre-treatment methods. The results obtained proved not only the applicability and high effectiveness of atmospheric-pressure plasma but also that plasma pre-treatment achieved distinctly better results in all areas than did the chemical reference method.

Covering a width of 150mm in the new installation, 48 plasma jets now clean thin gauge aluminium sheet on both sides before a conversion layer is applied (**Fig 6**). The metal sheet is then coated and shaped. The Plasmatreat installation not only accelerates the rate of production so far attained by a factor of four but also replaces a cleaning line 21m long. That is to say tonnes of chemicals and effluent are rendered unnecessary. The positive economical and environmental consequences of this are unique in the sector worldwide.

CLEANING FOR LAMINATION

To improve visual appearance door-finishing panels and kitchen panels are often laminated with films. The high mechanical stresses on such surfaces require very good and durable adhesion. Even small amounts of contaminants can later result in peeling of the film. By in-depth cleaning of the surfaces using plasma the optimal preconditions for long-term adhesion are created.

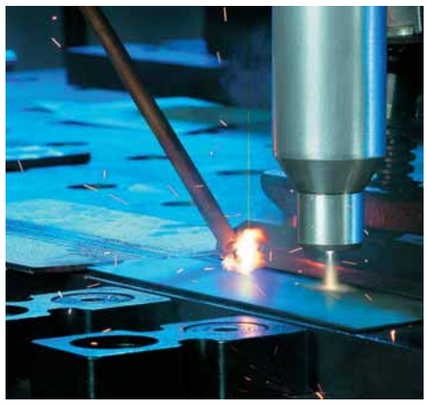
CLEANING FOR BONDING

The reflectors in the headlights of commercial vehicles are provided with a thin layer of aluminium by vapour-deposition in vacuum. The headlight lens

is then bonded into place. In this operation, however, the aluminium layer is not wanted in the bonding region because it can give rise to problems of adhesion and corrosive infiltration. Plasmatreat has developed a jet technique by means of which selective removal of the coating from the surface takes place. For this purpose a high-energy plasma is applied to the areas to be delayered and the layer of metal is very effectively removed. The improvement in quality achievable by this plasma application is frequently accompanied by a reduction of over 10% in wastage rates.

CLEANING FOR MIG WELDING

When metals are welded faults can occur in the welded joint due to the presence of impurities from the surface. During the welding operation volatile organic impurities pass over into the gas phase due to the input of heat and because of this give rise to small gas occlusions resulting in bubbles and pores. Apart from the poor visual appearance this can also have an effect on the strength of the welded joint. Surfaces cleaned and welded during Openair plasma treatment result in a distinct improvement in the process. The plasma acts intensively and selectively on the contaminated surface to ensure thorough cleaning around the joint and replaces the chemical cleaning methods hitherto used. The system has already been successfully used in a metal-inert-gas (MIG) welding process for aluminium-magnesium alloys (**Fig 7**).



7 Cleaning with Openair plasma prior to MIG welding

PLASTICS

Apart from cleaning and coating of metals, high activation of almost all plastics is also possible thus ensuring good adhesion of the most varied paints and adhesive systems to the surface.

Key advantages of using the Openair plasma process include its reliability and quality in production. Accordingly, the high demands imposed with regard to these criteria can be met. Furthermore, simple integration into process workflows can be achieved just as easily as higher efficiency in comparison with traditional methods – and at the same time the process is absolutely compatible with the environment.

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