Kaizen and plasma herald the future

Radical change: Instead of using solvents and primer, the LED surface-mounted machine lighting is pretreated environmentally safe with atmospheric pressure plasma before bonding.

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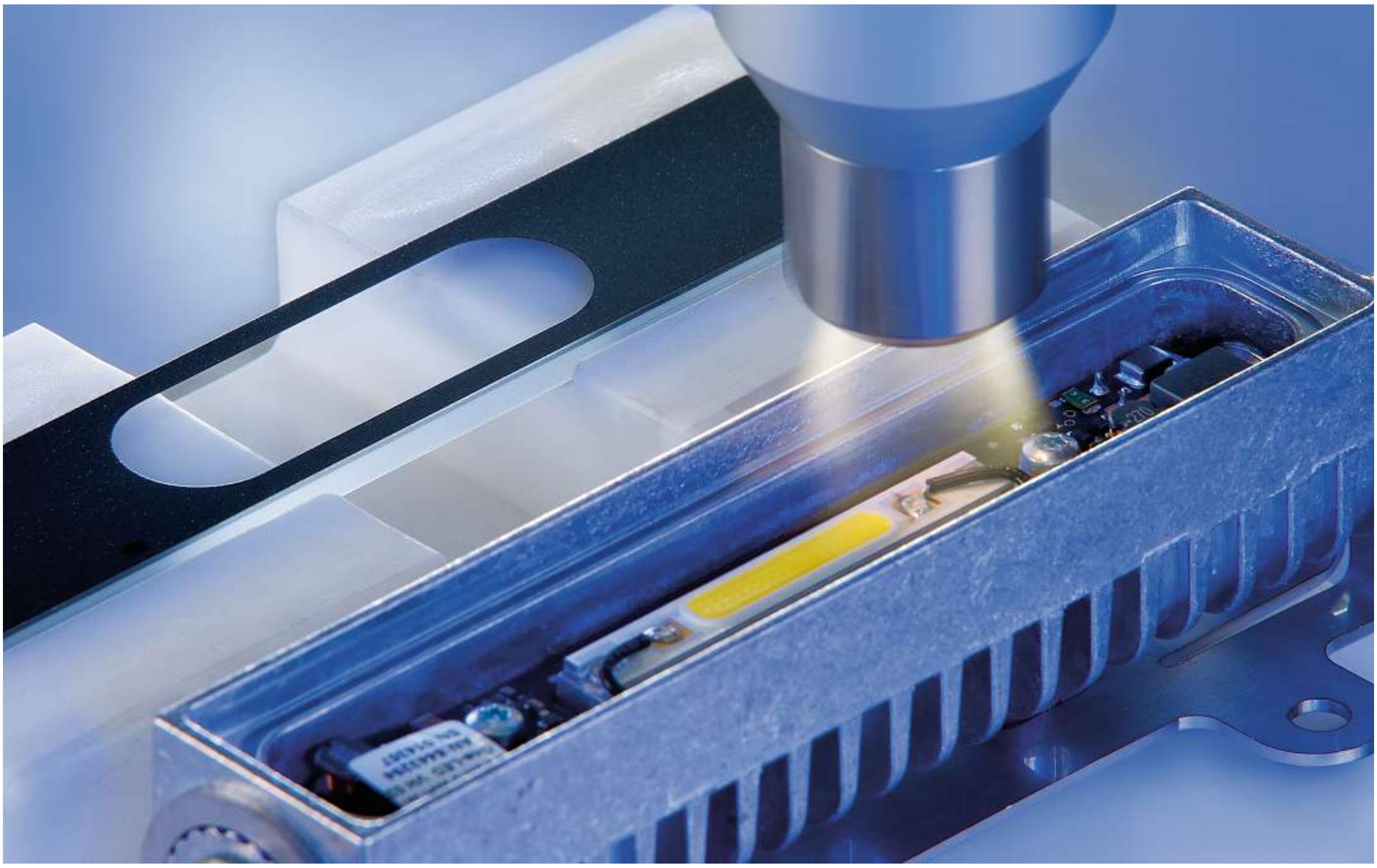

Photo: Plasmatreat

Fig. 1: *Harmless to electronics: Special Openair plasma rotary nozzles perform a virtually potential-free pretreatment of the aluminum lighting housing.*

For the employees of Herbert Waldmann GmbH & Co. KG from the Swabian town of Villingen-Schwenningen in Southern Germany, the year 2001 heralded a new era in production with the introduction of Kaizen, which translates as 'change for the better'. The family owned company is a leading developer and manufacturer of lighting, electrical and medical technology.

Inspired by this Japanese philosophy, company boss Gerhard Waldmann had converted the entire business to the "Just-in-time" production system. The process of continuous improvement extends to all levels of the company and affects every step of production from development to component production and finally to the end product.

High requirements for stability

One of the company's specialist areas is the production of industrial lighting, especially surface-mounted machine lighting. They are used to illuminate the interior of metal cutting machine tools, where lighting housings and panels are required to withstand flying metal chips (Fig. 2).

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But these lightings are also exposed to chemical substances such as cooling lubricants and oils. None of these must compromise the bonded joints, which is why the sealing requirements are extremely high. However, a strong, long-time stable bond invariably requires good pretreatment of the material surface. The use of wet-chemical substances that are harmful to the environment for the pretreatment of material surfaces is still one of the most widely used application methods.

It was no different at Waldmann. For years, an employee working in a separate room cleaned the adhesive surfaces by hand using a cotton cloth soaked in solvent-based isopropanol and a plastic cleaner. He then inserted the parts in an automatic priming station, where they were treated first with an activator and then again with a chemical adhesion promoter using a felt applicator. The fourth step was to remove the parts and air-dry them, and then finally transport them by trolley a distance of ten meters to the bonding station.

Not only was it harmful to the environment, the use of chemically reactive substances was associated with substantial additional costs for cleaning, materials and disposal. Other factors such as open times, shelf life and storage stability of the primer, as well as cleanliness of the rise cables in the station also had to be continuously monitored. The activator, adhesion promoter, spare parts, service and maintenance of the primer station alone incurred annual costs running into five figures. It was clear that the entire wet-chemical process should give way to an environmentally friendly and more efficient method. The only question was – which process was capable of replacing it and at the same time satisfying the stringent bonding requirements?

The change began when junior engineer Denis Stehle attended a seminar organized by adhesive manufacturer Rampf. Here he learnt at first hand from adhesive experts about a method for optimizing adhesion which he had previously only read about: the pretreatment of material surfaces with atmospheric pressure plasma (AP plasma), or more precisely, the Openair plasma technology from Plasmatreat.

Through the development of a plasma nozzle technique about 20 years ago the plasma systems engineer created a pretreatment process requiring nothing other than compressed air as the process gas and electrical energy. This prevents the emission of volatile organic compounds (VOC) during production from the outset. The process is used mainly on materials such as plastics, metals, glass and ceramics

Plasma technology suitable for sensitive components

When combined with fixed individual nozzles, this technology enables substrates to be transported through the plasma beam at speeds of several hundred meters per minute. The plasma system performs three operations in a single step lasting only a matter of seconds: It simultaneously brings about the dry, microfine cleaning, electrostatic discharging and activation of a surface. The result is homogeneous wettability of the material surface and long-time stable adhesion of the adhesive bond or coating even under challenging load conditions.

The area-selective plasma treatment renders the non-polar plastic polar at this defined place, thereby increasing its surface energy (Fig. 4). Aluminum and glass have naturally polar surfaces, but this surface energy which gives them their adhesive characteristics can be compromised by layers of dust deposits, grease and oils or other contaminants. This is where the microfine cleaning action of the plasma comes into play, revealing once again the high level of surface energy already present in the substrate. Materials can be further processed immediately after cleaning and activation with AP plasma.

Apart from the efficient and environmentally friendly performance of the process, Stehle was particularly impressed

Photo: Waldmann GmbH & Co. KG

Fig. 2: Surface-mounted machine lights must withstand extreme loads. The housings are pretreated with atmospheric pressure plasma to ensure seal tightness.

Photo :Plasmatreat

Fig. 3: Plasmatreat project manager Peter Langhof, Waldmann team leader Bruno Marano and engineer Denis Stehle (left to right) standing between the Openair plasma pretreatment station (back right) and the bonding station opposite

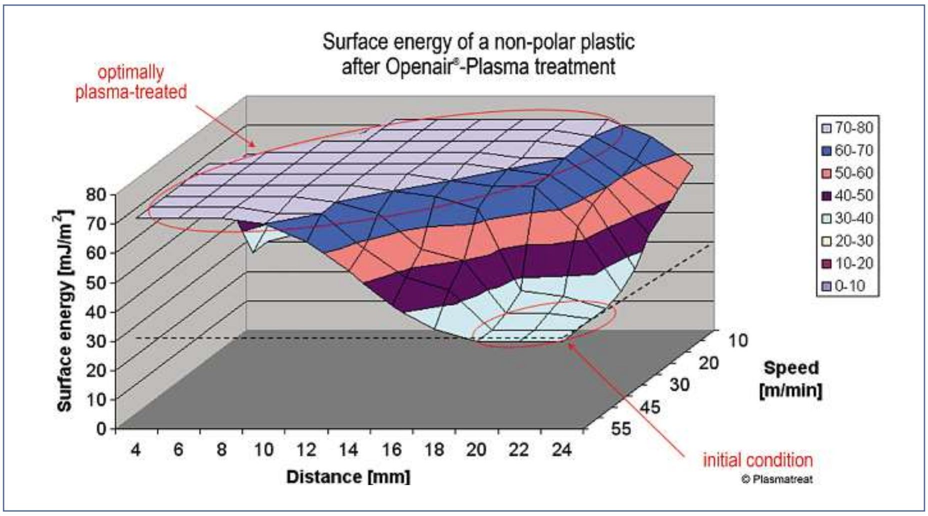

Diagram: Plasmatreat

Fig. 4: The figure shows a nonpolar plastic surface that was pretreated with plasma as a function of distance and speed. Treatment renders the surface polar and the surface tension rises to >72 dyne (mJ/m²) with a large process window.

by its apparent high process reliability, accurate reproducibility and on-screen monitoring facility. Just one thing gave him cause for concern. „The electronics are pre-installed in the housing we use for the ONE LED light“, he explained. „It was obvious to me that any pretreatment process that conducts electrical potential could cause short-circuits, leading to the destruction of electronic components.” For him, the ultimate question was: Would the electrical potential in the plasma beam damage the sensitive LED components?

Peter Langhof, Plasmatreat Marketing Manager Electronics, confirmed that his concerns were justified in principle, but explained that the Openair plasma technology had a special feature: In recent years Plasmatreat has developed special nozzles which discharge the electrical potential to the extent that the plasma impinging on the material surface is virtually potential-free. For this reason, it is now possible to pretreat even highly sensitive SMD assemblies and other delicate electronic components. Stehle presented the new pretreatment process to his company successfully. Waldmann decided to implement it immediately and ordered a plasma rental-system. The tests could begin.

From successful testing to serial production

Changing from one industrial process to a completely different one is a huge step which calls for a great deal of patience. Especially when the requirements for tight bonds are so high and the switch to the new pretreatment process is also accompanied by the introduction of a new adhesive. And if that were not enough, the pretreatment and bonding process was to be tested on not just one, but three different materials. The housings of the surface-mounted machine lights, which are up to 1.2 meters long, are made from anodized or hard-anodized aluminum. The panels protecting the electronics are made from ceramic-coated single pane safety glass or acrylic glass. The overall stability achieved through the combination of AP plasma and the new 1C-PUR adhesive had to be tested on these different surfaces, i.e. the bond between the adhesive and the materials and the strength of the adhesive itself.

During the 18-month test phase, Waldmann explored the uppermost limits of what an adhesive bond subsequently exposed to challenging chemical load conditions would have to endure. The microfine cleaning and activation power of the plasma was easy to demonstrate: Test ink measurements carried out before plasma treatment revealed surface tensions of < 44 dyne for aluminum, < 36 dyne for glass and 40 dyne for plastic. After plasma activation, values ranging from > 56 dyne to 72 dyne were measured on all three substrates, which corresponds to the modified energy values of the material surfaces.

There then followed a series of tests including single-lap shear and tensile shear strength tests (DIN-EN 1465), constant humidity climate tests (DIN EN ISO 6270-2), climate cycling tests (BMW 308 KWT) and 1000-hour storage of several adhesive samples at 30°C in different cooling lubricants and oils. “But the all-important adhesive test to confirm the long-term stability and safety of use of the adhesive bond”, says Stehle “was the cataplasma test, the sole purpose of which is to destroy the entire adhesive bond.” However, the accelerated ageing test simulated in the laboratory failed to achieve this objective. The plasma adhesive bond withstood even this.

In autumn 2015 a plasma unit, operated by a CNC 3 axis motion system as well as a new bonding machine were integrated into series production. Using this plasma technology has eliminated two entire process steps, and also dispensed with the need for drying times and interim storage. The plasma system equipped with a potential-free rotary nozzle now operates for eight to twelve hours a day in a continuous process and treats 1000 lighting housings per week. The LED electronics in all the lights work perfectly and the high level of process reliability has long since been proven too. According to Stehle, not only has the plasma treatment created the ideal conditions for bonding, the process demonstrably improves the surface quality and long-term behavior of the adhesive bond as well.

“Kaizen never ends”, explains Ralf Storz, plant organizer at Waldmann. “The plasma and bonding stations were positioned in relation to the material flow to prevent any retrograde steps, in other words they are fully integrated in the value stream. The climatic chamber where the bonded parts and adhesive are placed to cure is only three meters away. After a drying time of twelve hours, the lights are transported directly to the assembly station without any detours according to the flow principle.”

The use of Openair plasma technology and the associated rationalization and high optimization of the pretreatment process represents another milestone in the lighting manufacturer‘s process of continuous improvement. Change for the better – it has paid off. **// AI**

Plasmatreat / Waldmann