NEUE TECHNOLOGIEN KOSTENEFFIZIENZ ERHÖHTE MARKTCHANCEN

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PLAST VERARBEITER

Januar 2008
59. Jahrgang
D 5614
www.plastverarbeiter.de
unverb. Preisempfehlung
19,- Euro

DIE WELLE MACHEN

Maßhaltigkeit im Fokus: Bauteile für Geldautomaten automatisiert umspritzen, Seite 14

Hüthig
erfolgsmedien für experten

Adapted version from the German original. PLASTVERARBEITER January 2008, pp. 20-21

CLEAN AFFAIR

PLASMA TECHNOLOGY FOR CLEANING SURFACES. The fact that two of the world's largest liquefied natural gas tankers are now cruising the oceans is due in no small measure to a decisive contribution made by an atmospheric-pressure plasma process. In the shipyard where the tankers were built a very complex insulation process was carried out in the interior of the ships. This only became possible due to the deployment of this special technology for surface cleaning.

Giant LNG membrane carriers – 300m long and 50m high – transport the liquefied natural gas across the oceans.
Photo: Yves Guillotin

In the construction of membrane tankers for transporting liquefied natural gas (LNG) a new insulation technology developed by the tank system manufacturer Gaztransport & Technigaz (GTT) was to be used for the first time for insulating tankers. In doing so, due the thinner-walled construction of the insulating layers the capacity of the tankers would be increased by 8,000 m^3. The megatankers have four separate tanks having a total cargo volume of 153,500 m^3. The membrane systems developed by the tank system manufacturer are not self-supporting. The double skin of the ship's hull forms the actual load-bearing tank structure. The cargo tanks are adapted to the shape of the ship and integrated into the hull. Two barriers known as membrane layers serve for sealing and safety.

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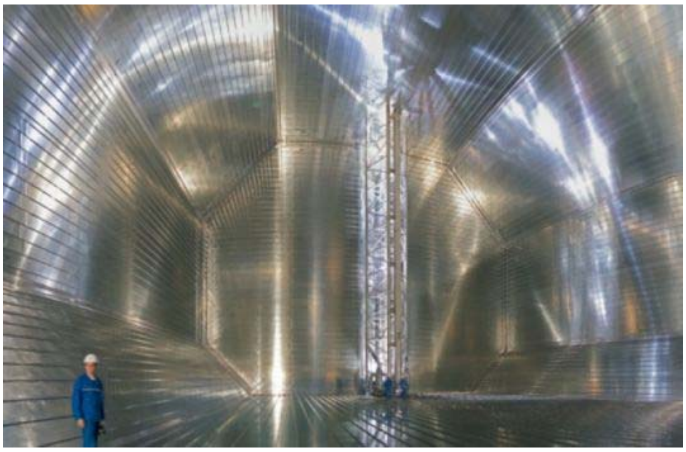

Photo: Yves Guillotin
A 0.7 mm thick metal membrane of invar steel forms the first barrier in the tank; it is in direct contact with the liquefied natural gas at a temperature of -163 °C.

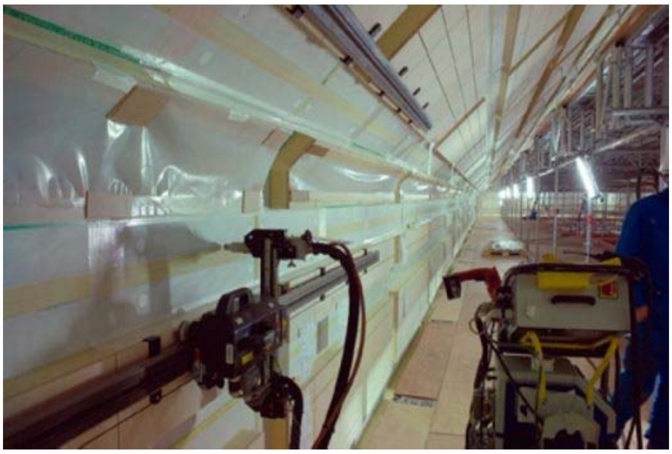

Photo: Yves Guillotin
The robot guides the plasma jet fully automatically over the surface to be treated.

Four insulating layers

The insulating structure consists of four levels. The inner, impermeable metal membrane forms the actual cargo container and thus is in direct contact with the liquefied gas. This first barrier consists of a 0.7 mm thick membrane of invar steel, an alloy having a very low coefficient of thermal expansion. Located behind this is an insulating layer composed of plywood and 10 cm of expanded polyurethane foam. This is followed by a thin Triplex membrane – the key characteristic of this technology. Previously in membrane tankers the second barrier was also manufactured from invar steel. The membrane consists of two outer glass fibre components and an intervening aluminium layer. This composite material together with the Triplex strips to be applied later forms the second watertight barrier. Between the Triplex membrane and the inside of the inner metal hull of the ship there is a further 20 cm thick layer of expanded polyurethane.

Photo: Plasmatreat
Zero-potential Openair plasma brings about ultrafine cleaning, high activation as well as selective nano coating of the surfaces of materials.

Precision pretreatment

The insulating composite material was adhesively bonded directly to the inner skin of the ship's double metal skin. Both barriers, but in particular the insulating layer of the second barrier, should prevent the extremely cold liquefied gas coming into contact with the steel wall of the ship's hull and rendering the latter brittle due to the very low temperature. Here surface treatment with Openair plasma was carried out on the level of the second barrier. The purpose was to make preparations for the bonding process for thousands of flexible Triplex strips. The strips were 30 cm wide and had a total length in each tanker of 40 km. With them and a two-pack epoxide adhesive the edge seams of the 1 x 3 m insulating panels were bonded over to ensure really tight sealing. The shipyard tested different methods but neither chemical methods nor flame treatment of the surfaces yielded the desired success. Only the use of atmospheric-pressure plasma technology fulfilled all the environmental, safety and efficiency conditions.

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New technologies

Electrically neutral plasma beam
The plasma systems based on a jet principle operate at atmospheric pressure and with the aid of an arc ignited in the jet and the working gas, air, generate a plasma that flows at zero potential onto the product to be treated. It contains particles sufficiently excited to initiate selective oxidation processes on the surface. A special feature is that the emergent plasma beam is electrically neutral which greatly expands and simplifies its range of applications. Its intensity is so high that machining speeds of several 100 m/min can be attained. The Openair system is characterised by a triple action: it activates the surface by selective oxidation processes, simultaneously discharges said surface and brings about ultrafine cleaning and high activation of the surfaces of metals, plastics and glass. Furthermore, the process is environmentally friendly. The jets are operated solely by air, if need be with a desired process gas also, and by high voltage. Typical temperature rises during treatment, on plastic surfaces for example, amount to less than 20 °C.

Use in LNG tankers
The pretreatment solution for the tankers involved the use for the first time in a large-area application of a rotating jet integrated into the robots. This jet generates plasma without any risk of overheating. Workers first of all fitted a 3 m long auxiliary rail for the robots in front of the surface to be treated. Once the starting and end points had been programmed the robot controlled the precise sequence of operations of the jet and drove it fully automatically at a speed of 6 m/min and at a spacing of 10 mm over the surface to be treated.

In doing so the plasma exercised a twin action on the Triplex polymer. On the one hand, the microcleaning caused the destruction of all organic substances on the surface due to the plasma beam striking the surface at 200 m/sec. On the other hand, the treatment activated the surface tension of the surfaces to over 72 mN/m. At the end of the operation the auxiliary rail was dismantled and set up afresh at the next area to be treated. In a second step an other team of workers carried out the actual adhesive bonding process and bonded over the surface treated by the plasma process with Triplex strip.

The process can also be used for many other cleaning and coating processes; it is capable of in-line integration and compatible with robots. The manufacturer has succeeded in rationalising processes such as the removal of mould release agents from PU mouldings. Layer-by-layer removal of organic coatings, removal of paint or partial removal of metallised coatings prior to bonding, the production of car headlights and the treatment of reflectors are just some examples of the in-line use of the plasma process. A further example is that after pretreatment with this plasma technology polycarbonate windows can be glued into the housing half shells of mobile telephones using solvent-free UV adhesives. Casein adhesives can equally well be used for labelling plastic drums.

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