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Effect of Pre-bonding Storage Period on Laser-treated Al Surfaces

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Abstract : In recent years, the use of aluminium has further expanded and is expected to replace steel in the future as vehicles become lighter and more recyclable in order to reduce greenhouse gas (GHG) emissions and improve fuel economy. In line with this, structures and components are becoming increasingly multi-material, with different materials, including aluminium, being used in combination to improve mechanical utility and performance. A common method of assembling dissimilar materials is mechanical fastening, but it has several drawbacks, such as increased manufacturing processes and the influence of substrate-specific mechanical properties. Adhesive bonding and fusion bonding are methods that overcome the above disadvantages. In these two joining methods, surface pre-treatment of the substrate is always necessary to ensure the strength and durability of the joint. Previous studies have shown that laser surface treatment improves the strength and durability of the joint. Yan et al. showed that laser surface treatment of aluminium alloys changes α-Al2O3 in the oxide layer to γ-Al2O3. As γ-Al2O3 has a large specific surface area, is very porous and chemically active, laser-treated aluminium surfaces are expected to undergo physico-chemical changes over time and adsorb moisture and organic substances from the air or storage atmosphere. The impurities accumulated on the laser-treated surface may be released at the adhesive and bonding interface by the heat input to the bonding system during the joining phase, affecting the strength and durability of the joint. However, only a few studies have discussed the effect of such storage periods on laser-treated surfaces. This paper, therefore, investigates the ageing of laser-treated aluminium alloy surfaces through thermal analysis, electrochemical analysis and microstructural observations.AlMg3 of 0.5 mm and 1.5 mm thickness was cut using a water-jet cutting machine, cleaned and degreased with isopropanol and surface pre-treated with a pulsed fibre laser at 1060 nm wavelength, 70 W maximum power and 55 kHz repetition frequency. The aluminium surface was then analysed using SEM, thermogravimetric analysis (TGA), Fourier transform infrared spectroscopy (FTIR) and cyclic voltammetry (CV) after storage in air for various periods ranging from one day to several months TGA and FTIR analysed impurities adsorbed on the aluminium surface, while CV revealed changes in the true electrochemically active surface area. SEM also revealed visual changes on the treated surface. In summary, the changes in the laser-treated aluminium surface with storage time were investigated, and the final results were used to determine the appropriate storage period.

Keywords : laser surface treatment, pre-treatment, adhesion, bonding, corrosion, durability, dissimilar material interface, automotive, aluminium alloys
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