Effect of contamination on the mechanical properties of aluminum-silicone adhesive joints


Introduction

When contamination is present at the surface of adhesive joints with metallic substrates, it can either remain at the adhesive/substrate interface (Figure 1), resulting in a physical separation between them, or be absorbed by the adhesive, changing its properties, particularly at the interphase (Figure 2).

Figure 1 – Contamination and the adhesive/substrate interface.

Figure 2 – Contamination absorbed by the adhesive at the interphase.

The contaminant considered in this work is a surfactant used to clean oil from aluminum, after the manufacturing of the component.

Experimental details

The strength properties of the contaminated joints with aluminum substrates and a silicone adhesive were analyzed using single lap joints (SLJ) and the fracture processes using double cantilever beams (DCB).

The substrates were treated with sandpaper and anodized. Afterwards, a water/surfactant mixture (with a concentration of 10 g/L) is applied to the substrate, with the contamination levels being established by the number of sprays deposited. It is also ensured that only surfactant is at the substrate prior to bonding (Figure 3).

Figure 3 – Substrate treatment procedure prior to bonding.

References


Acknowledgements

The authors wish to acknowledge and thank the funding and support provided by Robert Bosch GmbH, Corporate Research and Advance Engineering. The authors also gratefully acknowledge the funding provided by Fundação para a Ciência e Tecnologia (FCT), Portugal for the Ph.D. Grant 2020.06055.8D through FSE.

Conclusions

As the contamination at the surface of the substrate increases, the failure is progressively interfacial and the failure load decreases. Without contaminant both the DCB and SLJ exhibit cohesive failure, for 1 and 4 sprays of contamination, the failure path moves closer to the substrate, as the adhesive near the interface absorbs contaminant and weakens its mechanical properties, Figure 7a. As the contamination content increases, the adhesive becomes unable to absorb all the contaminant, leading to interfacial failure, Figure 7b.

Figure 7 – Contamination scenarios found for 1 and 4 sprays (a) and for 10 sprays (b).