PAPER REF: 3966

ADHESIVELY BONDED FUNCTIONALLY GRADED JOINTS

R.J.C. Carbas[1], L.F.M. da Silva[2(*)]

[1]Institute of Mechanical Engineering (IDMEC), Faculty of Engineering, University of Porto, Portugal
[2]Department of Mechanical Engineering, Faculty of Engineering, University of Porto, Portugal
[(*)]*Email:* lucas @fe.up.pt

ABSTRACT

The main objective of this work was to develop an adhesive functionally modified in order to have mechanical properties that vary gradually along the overlap, allowing a uniform stress distribution along the overlap. This allows for a stronger and more efficient adhesive joint. The adhesive stiffness would vary along the overlap, being maximum in the middle and minimum at the ends of the overlap.

In this study, grading is achieved by induction heating, giving a graded cure of the adhesive along the joint. The functionally graded joint was found to have a higher joint strength compared to the cases where the adhesive is cured uniformly at low temperature or at high temperature. Numerical modelling was performed to assist with the prediction and assessment of the possible effectiveness of a graded joint concept.

Keywords: epoxy adhesives, induction heating, functionally graded bondline, stress distribution, finite element stress analysis.

INTRODUCTION

The single lap joint with metallic or composite flat plates is the most common joint, mainly due to its simplicity and efficiency (Adams 2005). However, one of the problems associated to this joint is the fact that the stress distribution (shear and peel) is concentrated at the ends of the overlap. Techniques to attenuate this problem are the use of adhesive fillets, adherend shaping and rounding, mixed adhesive joints, or adhesive joints with functionally graded materials (da Silva *et al.*, 2011). But these techniques can be considered a rough version of a functionally graded material.

The main objective of the present project is to develop an adhesive functionally modified in order to have an adhesive with properties that vary gradually along the overlap allowing a uniform stress distribution along the overlap. This would permit to work with much smaller areas, reducing considerably the weight of the structure which is a key factor in the transport industry. It is an idea that has never been studied theoretically or experimentally. It is expected that with the present project an innovative technological process will be proposed in order to have a 'graded' joint in terms of mechanical behaviour.

EXPERIMENTAL AND NUMERICAL DETAILS

The grade joints were cured gradually along the overlap with induction heating. Single lap joints with steel adherend and two different types of adhesives (Araldite® 2011 from Huntsman and Loctite Hysol® 3422 from Henkel) were tested.

ABAQUS program was used for the numerical modelling to study the stress distribution and predict the joint strength.

RESULTS

The results from the tensile tests for adhesives Araldite® 2011 and Loctite Hysol® 3422 are shown in Fig. 1. Load-displacement curves are given for each adhesive for a graded cure and an isothermal cure.

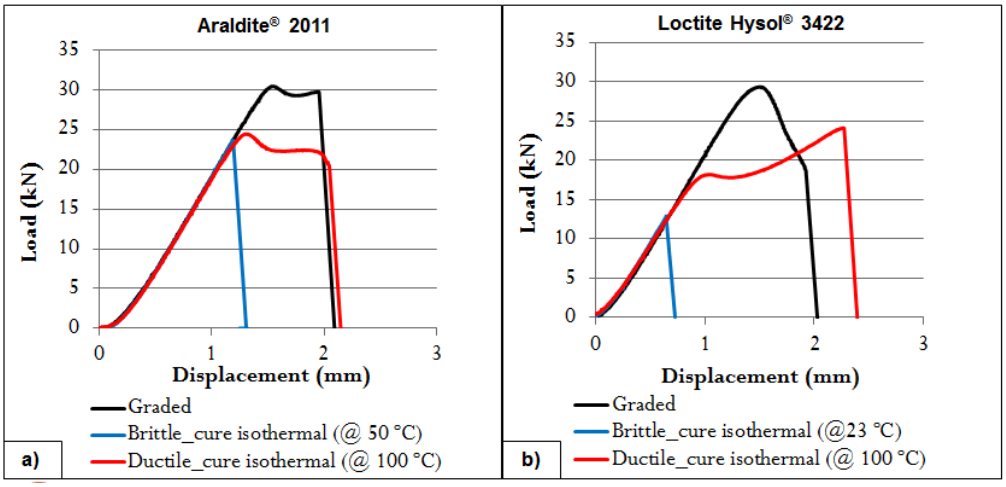

Fig. 1 - Tensile test results for adhesives Araldite® 2011(a)) and Loctite Hysol® 3422 (b))

CONCLUSIONS

This study shows that for the adhesive joints gradually modified by induction heating, there are reductions of the stress concentrations and a substantial increase of the joint strength. The functionally graded joint therefore gives a higher joint strength than the joints where the adhesive is cured uniformly at low temperature or at high temperature.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the funding by the Portuguese Science and Technology Foundation under the project PTDC / EME-PME / 098571 / 2008, Huntsman Iberia for supplying the adhesive Araldite® 2011 and Henkel Iberia for supplying adhesive Loctite Hysol® 3422.

REFERENCES

[1]-Adams, R.D. Adhesive bonding - Science, technology and applications. Cambridge: Woodhead Publishing Limited, 2005.

[2]-da Silva, Lucas F.M., Andreas Öchsner, and Robert D. Adams. Handbook of Adhesion Technology: Springer-Verlag Berlin Heidelberg, 2011.