Evaluation of the mechanical properties of an adhesive single lap joint using iron hollow spheres

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Introduction

Adhesive bonding has partly replaced traditional mechanical joining techniques for its versatility in bonding different types of materials. The single lap joint (SLJ) is largely used in industrial applications due to its simplicity and efficiency, as they provide smooth stress distributions along the width of the overlap. The main problem associated with the use of SLJs is the nonuniform stress distribution along the overlap length [1]. The goal of this work is to evaluate the reliability of the inclusion of iron hollow spheres on epoxy adhesive SLJs. Functionally graded adhesive joints (FGA joints) are to be made using an in house developed apparatus, shown in Figure 1.

Experimental methodology

To evaluate the influence of the iron hollow spheres on the epoxy adhesive, SLJs with three different particle contents (0%, 1% and 5%) and two distinct particle distributions (uniform and graded distribution) are to be tested, schematic representations can be seen in Figure 2.

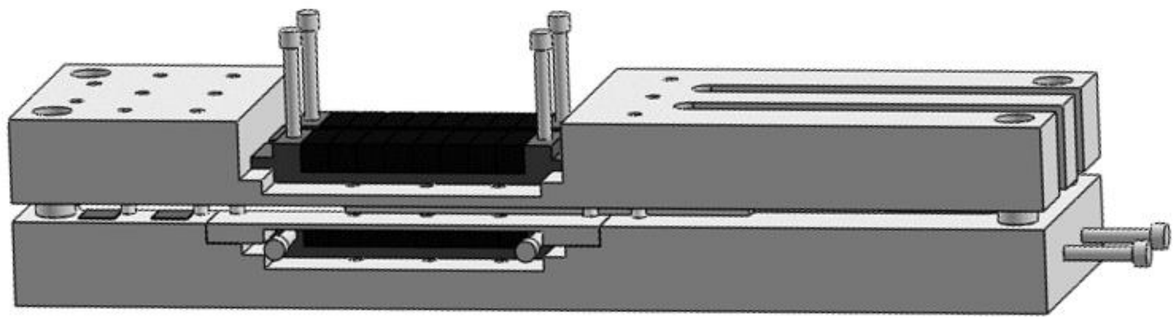

Figure 1 – Apparatus used to produce SLJs with graded particles distribution [2].

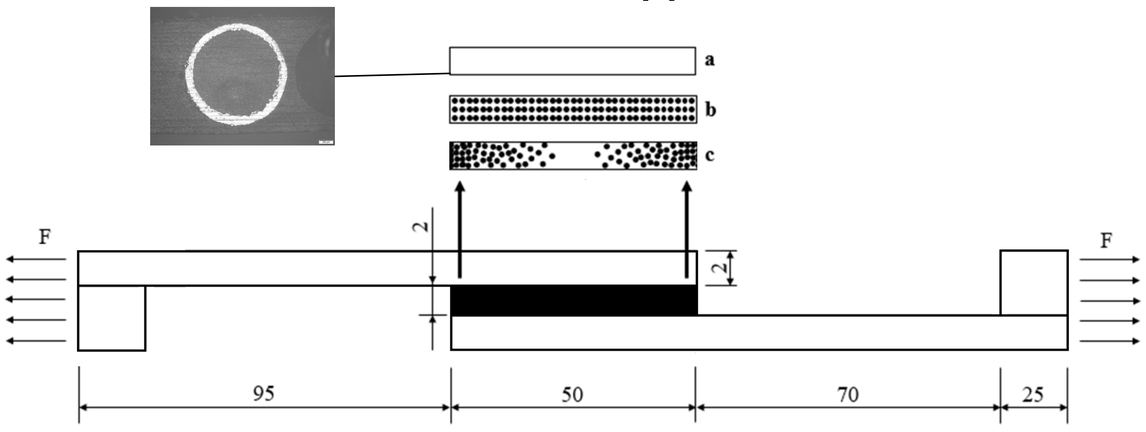

Figure 2 – Tested SLJs geometry: a) Neat, b) Uniform distribution, c) Graded distribution. On the left we can see a detail of a sectioned iron hollow sphere.

Ideally, a transparent epoxy adhesive would be used in this work to visually ensure that the wanted particle distribution is obtained. SLJs tests were performed using transparent adhesives, but cohesive failure was not obtained. As an alternative, Araldite® AV 138 was tested and cohesive failure was obtained. The grey colour of the adhesive makes it more difficult to obtain a graded spheres distribution, however, to make it possible, the methodology shown in Figure 3 will be followed. COMSOL® Multiphysics was used to predict the magnetic field intensity.

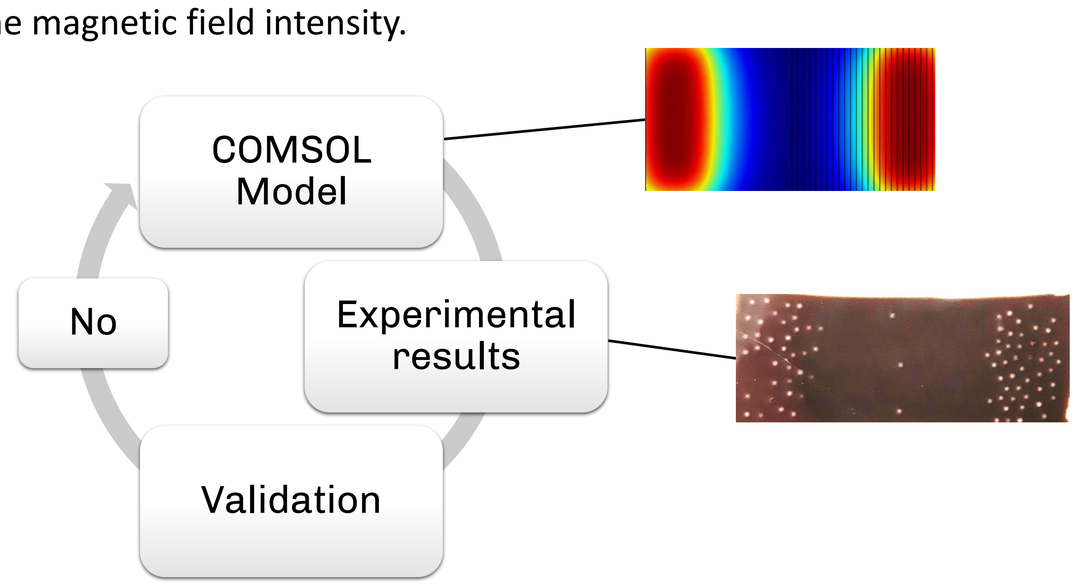

Figure 3 – Experimental methodology to achieve a graded iron hollow spheres distribution.

Experimental results

SLJs using adhesive Araldite® AV 138 were tested for neat and 5% uniform particle distribution. The results can be seen in Figure 4.

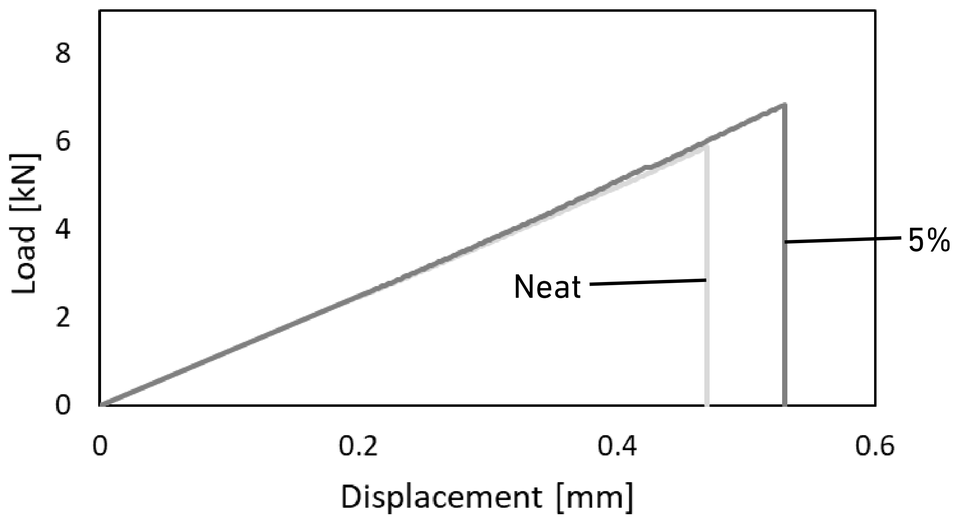

Figure 4 – SLJs results for the tested adhesive systems so far.

The SLJs with 5% iron hollow spheres particle content outperformed the neat joints by 17% both in terms of failure load and displacement at failure.

Future works

The proposed work aims to test three different spheres contents (neat, 1% and 5%) and two distinct spheres distributions (uniform and graded distribution). Testing SLJs with 1% spheres content and uniform distribution, and SLJs with 1% and 5% spheres content and graded distribution will be necessary to properly assess the effect of the iron hollow spheres on an epoxy adhesive. To do this, a manufacture process for the graded adhesive joint must first be validated.

References

[1] da Silva, Lucas FM, Andreas Öchsner, and Robert D. Adams, eds. *Handbook of adhesion technology*. Springer Science & Business Media, 2011.

[2] da Silva, Catarina I., et al. "Mechanical Characterisation of Graded Single Lap Joints Using Magnetised Cork Microparticles." *Advanced Joining Processes*. Springer, Singapore, 2020. 153-174.

Acknowledgements

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