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Evaluation of effective parameters on strength of metal specimen adhesion with polymers

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Abstract

To date usıng of the adhesively bonded joints are increased in aerospace and automotive industries. In this short review the effect of using patterns on the surface of fastened part on strength of the adhesive joint are examined. The adhesive samples are tested on the condition of statically and fatigue loads. The patterns are created by grooving the surface of sample. Grooving patterns orientation is changed from 0 to 90˚. For each orientation degree, results of the tests are compared with the test results of the non-treated sample. The results of this review shows creation of grooves on the surface of the fastened sample increase the strength of adhesion.

Review Article

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INTRODUCTION

Usage of adhesive bonding rather than mechanical fasteners offers the potential for reduced weight and cost[1]. Designers are not usually concerned with the as-manufactured strength of bonded joints, but with the lowest level to which the strength will fall during the life of the airplane due to adverse effects of the ambient environment''. This is a common assertion within the aerospace community that emphasises the most important, and yet probably least understood and most difficult aspect of adhesive bonding technology related to aircraft structures[2].

The single lap joint is the most studied type of adhesive joint in the literature. However, the joint strength prediction of such joints is still a controversial issue as it involves a lot of factors that are difficult to quantify such as the overlap length, the yielding of the adherend, the plasticity of the adhesive and the bondline thickness[3]. The single lap joint with metallic or composite flat plates is the most common, mainly, due to its simplicity and efficiency. The joint strength is influenced by many factors such as the type of adhesivesurface quality of the surface of adhesive samples.[4] It is generally believed that toughness enhancements in rough and patterned interfaces can be attributed to the increase in interface area, additional energy dissipation through inelastic deformation in the materials, and asperity interlocking with sliding and friction behind the crack tip[5].However, these mechanisms are not be necessarily active in all conditions. For example, a brittle bimaterial interface under mode I conditions with asperity interlocking but without any additional energy dissipation mechanisms, may necesssarily lead to unstable crack growth. In the model, that are be assume both materials, are elastic and each is assumed to be stronger than the interface thereby preventing crack penetration into either material. Finally, due to the local mode I nature of the applied remote load, asperity interlocking through contact behind the crack tip does not occur.[6]. Patterning at solid–solid interfaces is found in elastomeric contacts[7], grain boundaries in metal alloys and dislocation patterns in metals, A chart where the joint strength is given as a function of adhesive ductility and overlap have been porposed. The adherend is supposed to remain in the elastic range. This is not realistic since the substrates will yield in many cases[8].

A simple methodology to predict the joint strength have been developed. If the adhesive is very ductile, typically with more than 20% shear strain to failure and the adherends are elastic, the joint strength is given by

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the load corresponding to the total plastic deformation. If the adherends yield, the joint strength is governed by the adherends yielding independently of the type of adhesive[9]. The single lap joint with metallic or composite flat plates is the most common, mainly, due to its simplicity and efficiency. The joint strength is influenced by many factors such as the type of adhesive[4], the type of adherend, the overlap length[10] and the bondline thickness [11]. Adams and Peppiatt attribute the joint strength decrease with adhesive thickness to the fact that thicker bondlines contain more defects such as voids and microcracks[12]. Variuse arguments have been proposed in the literature to explain the influence of the bondline thickness. Interface stresses were shown to be higher for thicker bond lines[13]. The adherent thickness is also important for two reasons[14]. For low strength adherents, an increase in thickness is beneficial because the adherent becomes stronger and less likely to deform plastically.

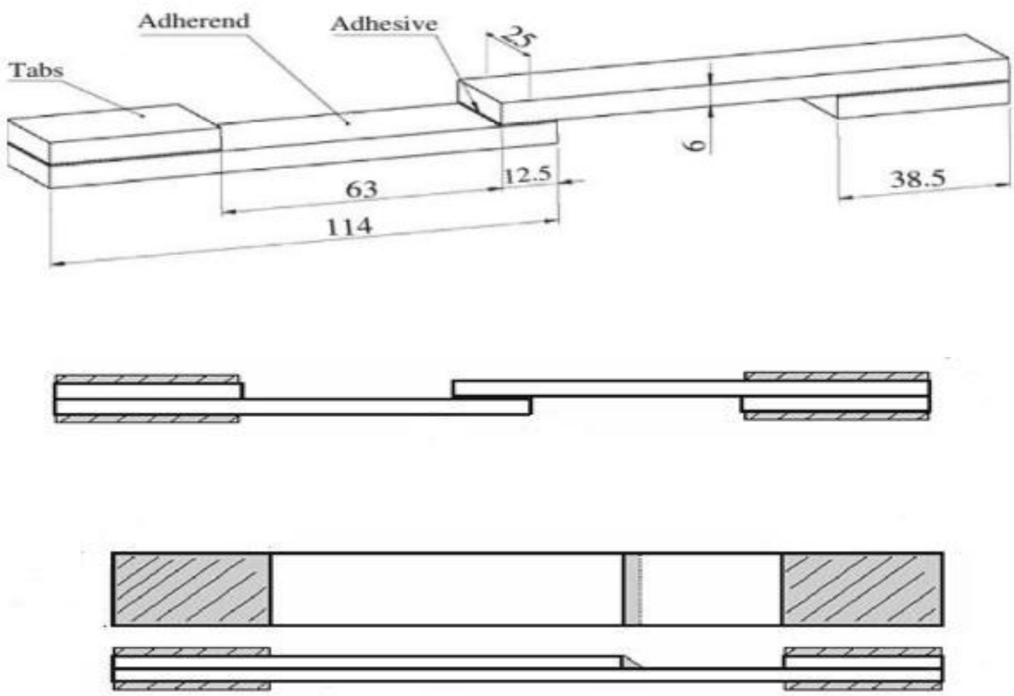

Fig 1.Schematic of lapjoint adhesion sample for statically tensile testing[15]

High strength adherents

On the other hand, for high strength adherents, a higher thickness can decrease the joint strength due to an increase of the bending moment. For a lap joint under tension, the longitudinal stress from the direct load and the bending moment at the edge of the overlap region creates plastic strains when the steel becomes plastic and these cause failure in the adhesive. The lap joint under tension is very sensitive to adhesive thickness. There is a longitudinal stress from the direct load together with an additional bending stress due to the load offset which is super-imposed on the tension stress. To reach the same stress level, as the bending moment increases, the smaller the stress due to direct load has to be. As the bond line thickness increases, there is an increase in the bending stress since the bending moment has increased. Consequently the strength of the joint is reduced[3]. The presence, or otherwise, of a surface treatment is another parameter that can significantly affect the joint strength. Most results in the literature are for mechanical treatments such as shot-blasting[16]. In any case, the type of failure must be cohesive in the adhesive and not interfacial so that the full capacity of the adhesive is achieved. If the failure takes place at the interface (adhesive failure), it means that the surface preparation needs to be improved. There are various adhesion theories that explain which phenomena take place at the interface[17].

Roughness

Roughness is a parameter that affects the strength of bonded joints, because it leads to an increased contact area between the two substrates and increases the adhesion by mechanical interlocking[18]. For metals, roughness may increase the resistance of the joint but for substrates with a low surface energy the increase of roughness does not have the same effect[15]. It was found that increasing surface roughness would lead to a higher interfacial bonding strength, although there was no clearly defined mathematical relationship[19].However, the relationship between the joint strength and the substrate roughness depends on other factors and cannot be expressed only as a function of the substrate roughness. Thus, it is considered that many of the surface treatments applied in order to generate roughness induce physical–chemical changes that can affect the surface energy of the substrates and wettability[20]. Hypothetically, an increase in the surface roughness would increase the number of crevices' and pores on the substrate surface. When liquid water is applied to the substrate surface, the water enters these crevices. As water expands upon freezing, firm anchoring points for the ice would be created in these crevices, increasing the degree of adhesion through mechanical means The objective of the present study was to quantify the influence of the adhesive, adhesive thicknesses, the overlap, and the surface treatment of adherent metals[21].

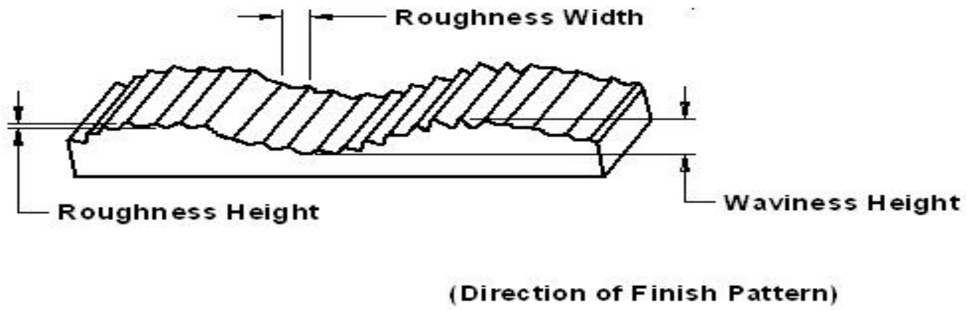

Fig 2. Schematic of the roughness of surface in patterns

CONCLUSION

The effective of surface treatment, adhesive and thickness of adhesive on strength of metal specimen adhision with polymers was evaluated. Tensile tests of joints with the brittle adhesive show that the surface patterns influence the joint strength. On the other hand tensile testing with the ductile adhesive shows that the surface patterns do not have a significant influence on the joint strength because the failure mode is already nearly cohesive in the case of no pattern. The lap shear strength decreases as the adhesive thickness increases. Also the lap shear strength increases as the adherend thickness decreases.Also that is included an increase in the surface roughness would increase the strength of adhesion.

REFERENCES

1. RD, A., 2005, Cambridge Woodhead Publishing Limited.
2. Sargent, J.P., *Durability studies for aerospace applications using peel and wedge tests.* International Journal of Adhesion and Adhesives, 2005. **25**(3): p. 247-256.
3. da Silva, L.F.M., et al., *Effect of material, geometry, surface treatment and environment on the shear strength of single lap joints.* International Journal of Adhesion and Adhesives, 2009. **29**(6): p. 621-632.
4. da Silva, L.F.M., G.W. Critchlow, and M.A.V. Figueiredo, *Parametric Study of Adhesively Bonded Single Lap Joints by the Taguchi Method.* Journal of Adhesion Science and Technology, 2008. **22**(13): p. 1477-1494.
5. Kim, W.S., et al., *Evaluation of mechanical interlock effect on adhesion strength of polymer-metal interfaces using micro-patterned surface topography.* International Journal of Adhesion and Adhesives, 2010. **30**(6): p. 408-417.
6. Howarth, J.A. and L.G. Hector, *A thermomechanical model of solidification on a mold moving with constant velocity.* Journal of Thermal Stresses, 2001. **24**(10): p. 937-985.
7. Shenoy, V. and A. Sharma, *Pattern formation in a thin solid film with interactions.* Physical Review Letters, 2001. **86**(1): p. 119-122.
8. LJ, H.-S., *NASA Contract Report*, 1973.
9. vanStraalen, I.J., et al., *Structural adhesive bonded joints in building engineering - Principles and requirements of design.* Euromat 97 - Proceedings of the 5th European Conference on Advanced Materials and Processes and Applications: Materials, Functionality & Design, Vol 4, 1997: p. 357-360.
10. Banea, M.D. and L.F.M. Silva, *Mechanical Characterization of Flexible Adhesives.* Journal of Adhesion, 2009. **85**(4-5): p. 261-285.
11. da Silva, L.F.M., et al., *Effect of adhesive type and thickness on the lap shear strength.* Journal of Adhesion, 2006. **82**(11): p. 1091-1115.
12. Adams, R.D. and N.A. Peppiatt, *Stress Analysis of Adhesive Bonded Tubular Lap Joints.* Journal of Adhesion, 1977. **9**(1): p. 1-18.
13. Gleich, D.M., M.J.L. Van Tooren, and A. Beukers, *Analysis and evaluation of bondline thickness effects on failure load in adhesively bonded structures.* Journal of Adhesion Science and Technology, 2001. **15**(9): p. 1091-1101.
14. Gledhill, R.A., S.J. Shaw, and D.A. Tod, *Durability of Adhesive-Bonded Joints Employing Organosilane Coupling Agents.* International Journal of Adhesion and Adhesives, 1990. **10**(3): p. 192-198.
15. Pinto, A.M.G., et al., *Shear strength of adhesively bonded polyolefins with minimal surface preparation.* International Journal of Adhesion and Adhesives, 2008. **28**(8): p. 452-456.
16. Gan, L.M., H.W.K. Ong, and T.L. Tan, *Surface-Treatment of Cold-Rolled Steel by Phosphating.* Journal of Adhesion, 1984. **16**(3): p. 233-244.
17. Chichester, *Handbook of adhesion.* 2005: John Wiley & Sons.
18. Buketov, A.V. and V.M. Krasnen'kyi, *Influence of the range of particle sizes of the filler on the adhesion*

strength and residual stresses in epoxy composites. Materials Science, 2013. **48**(4): p. 521-530.
19. Hassan, M.F., H.P. Lee, and S.P. Lim, *The variation of ice adhesion strength with substrate surface roughness.* Measurement Science & Technology, 2010. **21**(7).
20. Reina, J.M.A., J.J.N. Prieto, and C.A. Garcia, *Influence of the Surface Finish on the Shear Strength of Structural Adhesive Joints and Application Criteria in Manufacturing Processes.* Journal of Adhesion, 2009. **85**(6): p. 324-340.
21. M, L. and F. A, *Studies of ice adhesion: I.* Adhesion of ice to plasticsJ. Colloid Interface Sci., 1967. **25**: p. 231–44.