Numerical Analysis of the Nugget Location on the Weld-bonded Single Lap Aluminum Joint

Jian-Li LI[1, a], Min YOU[1, 2, c,*], Peng WANG[3, c], Hai-Zhou YU[2, d]

1 Hubei Three Gorges Polytechnic, Yichang 443000, China

2 Hubei Key Laboratory of Hydroelectric Machinery Design & Maintenance, China Three Gorges University, Yichang 443002, China

3 Wuhan Tower Works, Power Construction Corporation of china, Wuhan 430011, China

[a] ljl@tgc.edu.cn, [b] youmin@ctgu.edu.cn, [c] 597013645@qq.com.com, [d] yu_haizhou@yahoo.cn

*Corresponding author

Key words: Weld-bonded joint, Aluminum alloy, Nugget location, Stress distribution, FEA

Abstract. The effect of the nugget position on the stress distribution in aluminum single-lap weld-bonded joint was investigated using elasto-plastic finite element method (FEM). The results from the numerical analysis show that all the peak stresses of stress components *Sx, Sy, Sxy* and von Mises equivalent stress *Seqv* at the points near the left edge of the nugget along the bondline decreased greatly as the center of the nugget moved from the point near the left end to the center of the overlap zone. Meanwhile the peak stresses at the points near the right edge of the nugget is not varied significantly. The minimum value of the peak stress is occurred when both centers of the nugget and the overlap zone become the same one.

Introduction

The weld-bonded lap joint is widely used in the aerospace, railroad passenger cars and automobile industry for its higher fatigue strength and more uniform of the stress distribution in lap joint [1-3]. Darwish and Ghanya [1] pointed that weld-bonded joints enhanced the fatigue as well as the corrosion resistance of resistance welded joints. Darwish and Al-Samhan [2] found that the strength of weld-bonded joints increased with the increase of the elastic modulus of adherents. Some researches were carried out by the authors such as the effect of the elastic modulus of the adhesives for bondline [3] as well as for fillet [4] and the inner step length [5] on the stress distribution in weld-bonded aluminum single lap joints. The effect of the nuggets position on the stress distribution in weld-bonded aluminum double lap joints was investigated [6] and no work has been down with single lap joints.

Finite Element Model and Mesh

The model and mesh were built using the ANSYS finite element software as shown in Fig.1 and Fig.2a. The properties of the materials used in this study are listed in Table 1. The load applied was taken as 2 kN and the dimensions of the structural steel adherend were made in accordance with the Chinese standard GB 7124. The triangular element was used for both bondline and the nugget and quadrilateral element for adherend (Fig.2a).The thickness of the bondline was 0.2 mm and divided into 4 layers. The nugget was assumed in a shape of ellipsoid with a mayor axis a= 4 mm and minor axis b=1.2 mm. Five positions were taken into account with the center coordination as x= -4 mm, -3 mm, -2 mm, -1 mm and 0 mm (standard joint) respectively.

© 2016. The authors – Published by Atlantis Press

Table 1 Mechanical properties of the materials

Materials	Elastic Modulus (GPa)	Poisson's Ratio	Yield Strength (MPa)	Tang Modulus (MPa)
Aluminum alloy LY12	71	0.32	400	240
Nugget	102	0.29	800	210
Phenolic resin adhesive	2.875	0.42	90	500

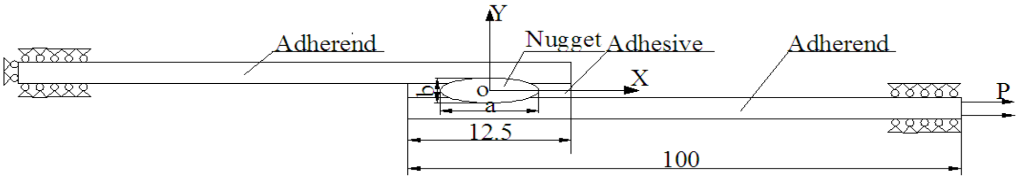
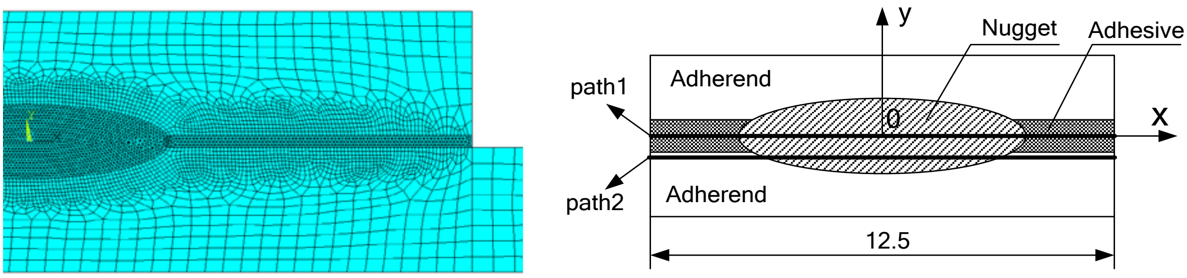


Fig.1 Finite element model (unit: mm)



(a) (b)

Fig.2 Finite-element meshes for right half of over lap zone (a) and paths (b): 1-along mid-bondline, 2-along adherend

Results and Discussion

The effect of the nugget location on the stress distribution along x axis (path1) is presented in Fig.3. The results from the simulation showed the peak values of the stress components *Sx*, *Sy*, *Sxy* and the von Mises equivalent stress *Seqv* in the left part of the over lap zone are significantly affected by the nugget location and it is decreased evidently as the nugget moved from the point near the left end to the center of the over lap zone. But for the peak value of the stress *Sx*, *Sy*, *Sxy* and *Seqv* occurred at the point near the right ends of the over lap zone in the joint, the difference is neglectable as the center of the nugget location varied from x= -4 mm to 0 (Fig. 3). For instance, the peak value of the longitudinal stress *Sx* is decreased about 83.5 % from about 62.4 MPa to about 10.3 MPa when the nugget location moved from x = - 4 mm to 0 mm (in Fig. 3a). Meanwhile it is almost the same at the point near the right end (10.4 MPa to 10.3 MPa). Compared the results with that reported in Ref. [6], the effect of the nugget location for the single lap joint is more significant than that of the double lap joint. It may be due to the difference in the study conditions such as lap zone length (12.5 mm to 25 mm) and joint (one nugget to two nuggets) etc. In Fig. 3d the value of the stress *Seqv* at the point near the left end of the lap zone is beyond 90 MPa so that failure of the joint might be occurred. It is suggested that be sure to avoid arranging the nugget far away from the center of the lap zone.

The effect of the nugget location on the stress distributed in the adherend near the interface (along path2) is shown in Fig.4. The results show that all the peak values of the stress components *Sx*, *Sy*, *Sxy* and the von Mises equivalent stress *Seqv* in the left part of the over lap zone are similar to that in the mid-bondline along the path1. In other words, more loads are carried by the nugget when it moved from left to the center of the lap zone. The stress distribution tendency of the von Mises equivalent stress *Seqv* (Fig. 4d) is similar to the longitudinal stress *Sx* (Fig. 4a).

© 2016. The authors – Published by Atlantis Press

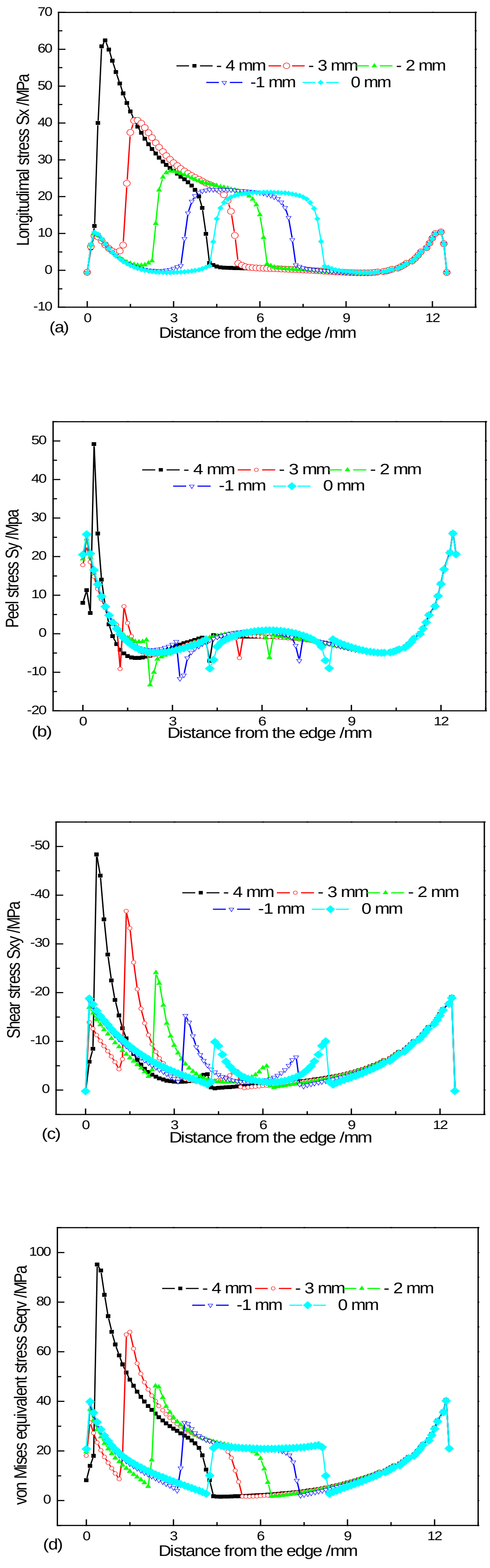


Fig.3 Effect of the nugget location on the stress distribution along the mid-bondline: (a) longitudinal stress Sx; (b) peel stress Sy; (c) shear stress Sxy and (d) von Mises equivalent stress Seqv

© 2016. The authors – Published by Atlantis Press

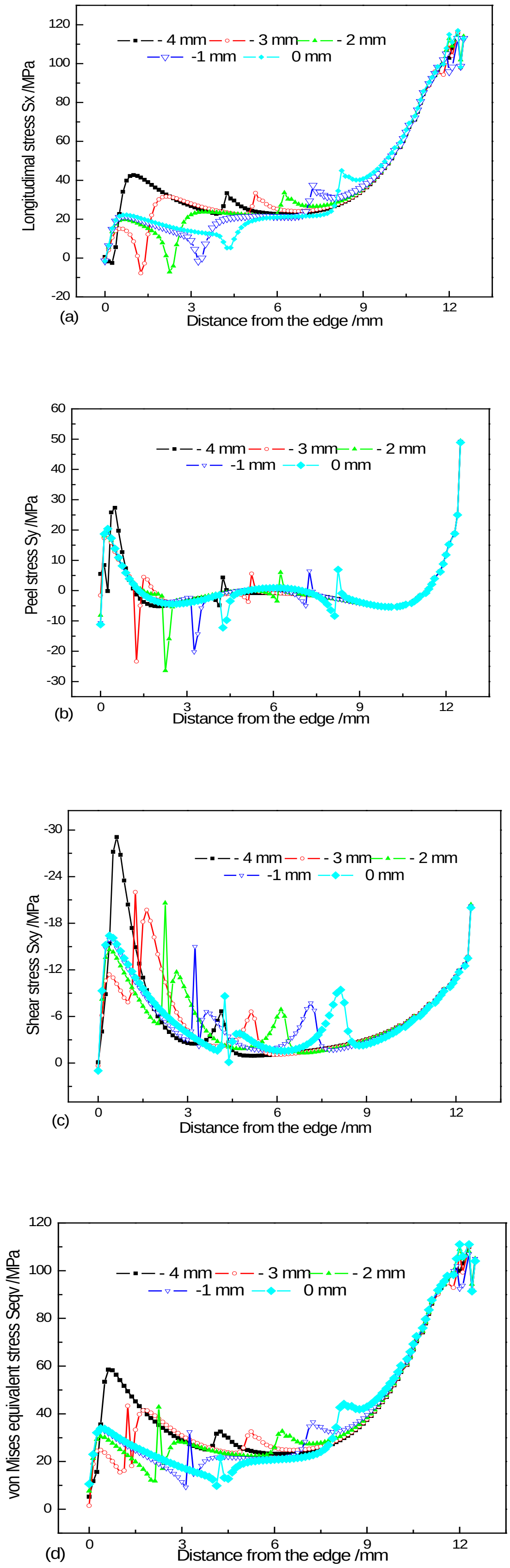


Fig.4 Effect of the nugget location on the stress distribution in adherend near the interface: (a) longitudinal stress Sx; (b) peel stress Sy; (c) shear stress Sxy and (d) von Mises equivalent stress Seqv.

© 2016. The authors – Published by Atlantis Press

Summary

The results show that the peak values of the stress components *Sx*, *Sy*, *Sxy* and the von Mises equivalent stress *Seqv* along the mid-bondline in the left part of the over lap zone are decreased significantly as the nugget location is moved from the point near left end to the center of the lap zone. Compared them with the results from the double lap joints, the effect of the nugget position is more significant on the peak values of the stresses in the left part of the lap zone.

There is no significant difference existed in the values of the peak stress occurred in the region within right half of the lap zone. The stress distribution tendency along the adherend near the interface is similar to that of along the mid-bondline in the left half of the lap zone for the joint. Under the research conditions, the suitable location of the nugget is set at the original point (x=0 mm) of the over lap zone for the weld-bonded single lap aluminum joint.

Acknowledgements

The authors would like to acknowledge the financial supported by the Hubei Province Natural Science Foundation of China under project no. 2014CFA123.

References

[1] S. M. Darwish and A. Ghanya, Critical assessment of weld-bonded technologies, J. Mater. Proc. Technol., 105 (2000) 221-229

[2] S. M. Darwish and A. Al-Samhan, Design rationale of weld-bonded joints, Int. J. Adhesion & Adhesives, 24 (2004) 367–377

[3] M. You, J. -L. Yan, X. -L. Zheng, et al, Effect of elastic modulus of adhesives on stress distribution in weld-bonded joints, J. Aeronaut. Mater., 29 (n3, 2009) 98-101 (In Chinese).

[4] M. You, J. -L. Yan, X. -L. Zheng, et al, Effect of adhesive for fillet on stress in weld-bonded joints. Key Eng. Mater., 450 (2011) 502-505

[5] J.-L Li, P. Wang, M. You, Effect of inner step length on the stress distribution in weld-bonded single lap aluminum joint: accepted by Materials Science Forum (2016)

[6] M. You, Z. Li, M. -R. Zhao, et al, Numerical analysis on stress distribution in adhesive-welded double lap joint of aluminum, Trans. China Weld. Inst., 30 (n11,2008) 13-16 (In Chinese).

© 2016. The authors – Published by Atlantis Press