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Influences of Glue-welding Combination on Stress Distribution in Weldbonding Joint

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Abstract: Use elastoplastic finite element method to analyze the combination effect influence of weldbonding joint. It can be seen from paper that as to the weldbonding joints under peeling and bending load; the reinforcement of the glue-welding combination is relied on the adhesiveness between the glue and the welding point. Disconnect the glue layer from the welding point to disintegrate the glue-welding combination, leaving the glue layer barely loaded and the stress concentration in the welding point becomes very significant and the stress peak of the joint increases drastically, with the bearing capacity and rigidity of the reinforced joint drops considerably. Therefore, adhesion quality is key to the Weldbonding joint under peeling load and must be guaranteed. Therefore, the composition of the existing epoxy glue shall be modified; also shall new approaches be probed in order to enhance the elastic modulus of the epoxy glue, e.g., to develop new additives to improve the performance of the glue, in order to excavate its potential high strength.

Key words: Glue-welding combination, stress distribution, peeling load, bending load

INTRODUCTION

Because manufacturers are constantly being pressurized for lower cost, enhanced mechanical and thermal properties and reduced weight, multiple materials are being combined in many products. For example, spot-welded brass/steel sheets have many industrial applications in radiator-car body connections, condensers and heat exchangers (Cannell and Sessions, 1997). As different materials are used within a given structure, there will most definitely be a need to somehow join them. Of the promising methods being considered for the joining of dissimilar materials is resistance welding and weldbonding (Satoh *et al*., 1996).

The authors study the influence of the elastic modulus of adhesives and nuggets position on the stress distribution in adhesive-welded double lap joints of aluminum was investigated by elastic-plastic Finite Element Method (FEM). The results obtained show that the influence of the elastic modulus of adhesive on the stress distribution in adhesive-welded double lap joints of aluminum is significant. the load bearing ability of the adhesive-welded double lap joints of aluminum can be improved by lower elastic modulus adhesive and the center overlapping of the nugget and the lap zone (You *et al*., 2009).

FINITE ELEMENT MODEL AND MESH

The sample is made according to the national standard GB7122-96 Determination of Peeling Strength of High-Strength Glues: Floating Roller Method, with the adherend 25 mm in width, 0.8 mm in thickness and the overlapping area 16 mm in length, the glue layer 0.2 mm in thickness. The welding spot is ovally shaped with the long axis of 2.5 mm and the short axis of 0.5 mm, with its ovarian center 9 mm apart from the frontal end of the joint, as shown in Fig. 1. In analysis the possible defects like air pores and sundries in the glue layer are neglected. Considering the nonlinear behaviors of the material, the elastoplasticity of the material is described by bilinear isotropic hardening options, as shown in Table 1 and the VonMises yield criterion is adopted. The ANSYS software is used in modeling and mesh generation with elements 0.05 mm in size which is further detailed close to the glues or the welding spots.

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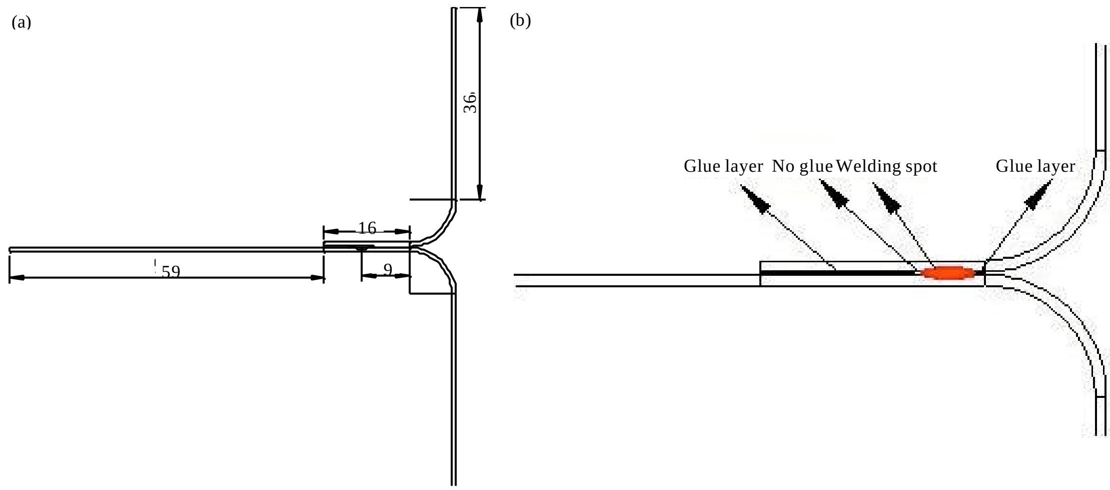

Fig. 1(a-b): Size of joint peeling sample and location of welding spot, (a) Peeling sample size and welding spot location and (b) Zooming-in of welding spot location

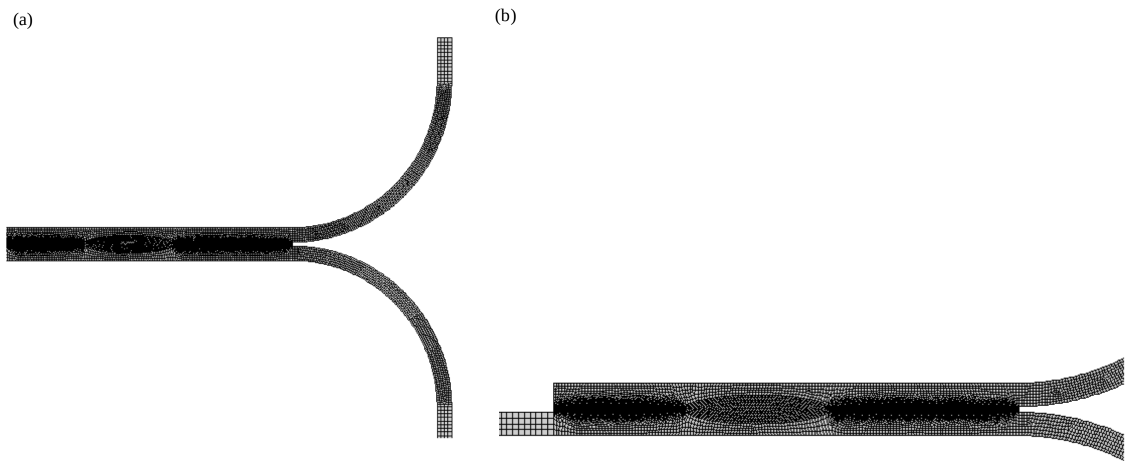

Fig. 2(a-b): Grid of overlap area strip connector diagram. (a) Model grid and (b) adhesive layer and Welding point grid

Table 1: Mechanical properties of materials

Materials	Modulus of elasticity E/Gpa	Poisson's Ratio V Er/Mpa	Yield Strength σ_y/Mpa	Hardening Modulus E/Gpa
LY12	71.000	0.32	400	240
Acrylic resin adhesive	0.050	0.45	40	40
Phenolic resin adhesive	1.888	0.33	50	50
Epoxy resin adhesive	2.875	0.42	90	500

The bending samples are made according to the national standard GB7124-86 Determination of Tensile Shear Strength of Glues (Metal-on-Metal), each 100 mm long, 25 mm wide and 2 mm high with 0.2 mm-thick glue layer. Regardless of the effects of electrode impression, the welding spot is oval-shaped with the long axis of 2 mm and short axis of 0.4 mm, the spot center 6.25 mm apart from the frontal part of the joint, as shown in Fig. 3. In any analysis the possible defects like air pores and sundries in the glue layer are neglected. Considering the nonlinear behaviors of the material, the elastoplasticity of the material is described by bilinear isotropic hardening options, as shown in table 1 and the Von Mises yield criterion is adopted. The model is analyzed by elastoplastic FEM under concentrated load F = 4 KN, with all characteristics of the glue and the adhered subject kept unchanged.

The generalized plane strain element PLANE183 is introduced in the analysis of the glue and the adhered, with the 3-D deformations simulated by 2-D element options. Since the strain through the thickness direction can not be neglected under the bending load, the characteristic option of the element type should be set as

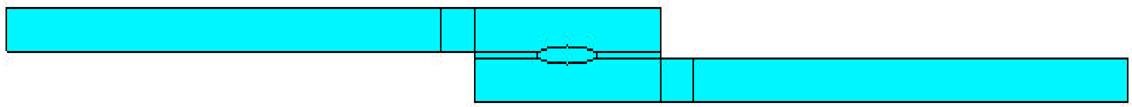

Fig. 3: Bending sample and welding spot positions

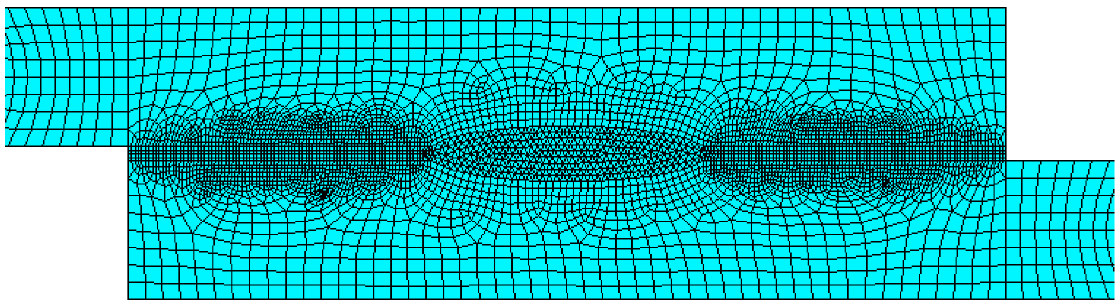

Fig. 4: Lapping area and meshed welding spots of bending sample

Plane Stress (with Thickness) in calculation. The ANSYS software is used in modeling and mesh generation, with the glue layer and welding spots divided into triangular elements and the adhered subjects divided into quadrilateral elements 0.05mm in size; the meshes close to the glues or the welding spots are further detailed, as shown in Fig. 4. The center of the glue layer is chosen as the path of stress analysis to observe the stress distribution in such layer.

NUMERICAL RESULTS ANALYSIS AND DISCUSSION

The elastoplastic finite element method is used to analyze the model. All the stressed loads are the loads uniformly distributed δ = 5 Mpa. In the loading process, it is assumed that the properties of both adhesive and adherend material will not change. In order to investigate the distribution of stress in the adhesive layer, the center of adhesive layer is selected as the path of stress analysis.

Influences of glue-welding combination on stress distribution in weldbonding joint under peeling load: Figure 5 shows the influence of glue-welding combination on stress distribution in reinforced glued joint under peeling stress. “Common” refers to the glue-welding combination joints while “adhesive failure” refers to joints without glue-welding combination.

It can be seen from Fig. 5 that as to the Weldbonding joints under peeling stress; the reinforcement of the glue-welding combination is relied on the adhesiveness between the glue and the welding point. Disconnect the glue layer from the welding point to disintegrate the glue-welding combination, leaving the glue layer barely loaded and the stress concentration in the welding point becomes very significant and the stress peak of the joint increases drastically, with the bearing capacity and rigidity of the reinforced joint drops considerably.

The influence of the glue-welding combination is remarkable particularly on the Weldbonding joint under peeling load, with significant effects on all stresses the joint is subject to. Take SEQV for example, the stress of the welding point with adhesive failure is 197.78 Mpa, comparing to 12.38 Mpa of that without such failure. Therefore, adhesion quality is key to the Weldbonding joint under peeling load and must be guaranteed.

Influences of glue-welding combination on stress distribution in weldbonding joint under bending load: In Fig. 4 is the influence of elastic modulus on the stress distribution of weldbonded joint under the pealing load. Here, the peeling weldbonded joints with the distance from the center of welding point to the front end L = 2.5 cm are selected as the models to research the influence of elastic modulus on the stress distribution of weldbonded joint under the peeling load. The calculation result is as shown in Fig. 4. From Fig. 4e, it can be learned that the peak value of stress still appear on the welding point and will decrease with the increase of elastic

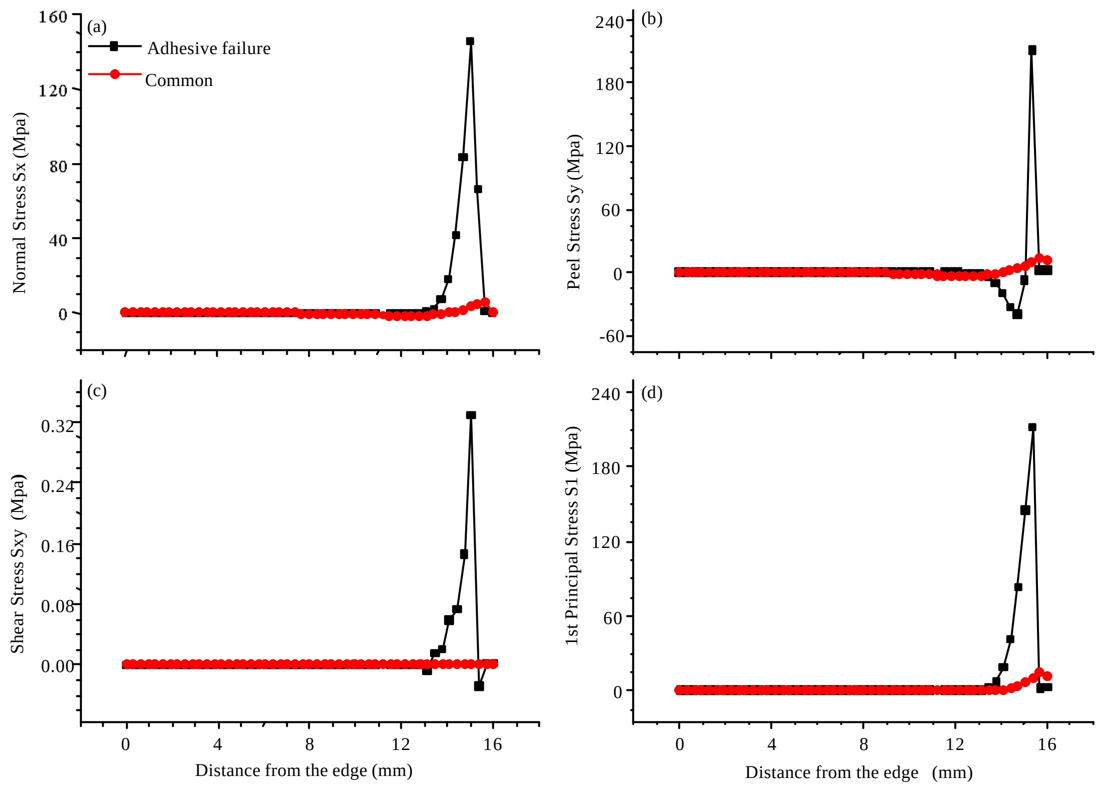

Fig. 5(a-d): Influences of glue-welding combination on stress distribution in reinforced glued joint under peeling load

modulus of adhesive. For example, the peeling stress SY, as shown in Fig. 4.8b, increased by about 70.88% from about 110.09 Mpa corresponding to the adhesive of 2875-188.13 Mpa. This rule is just contrary to the rule that the peeling joint of common T type adhesive will increase with the increase of the elastic modulus of adhesive. It is because, when the T type weldbonded joint bears the load and the coordination between adhesive of low elastic modulus and welding point is deformed, the stress differences of 2 stresses will increase, the adhesive layer of low elastic modulus hardly bear any load, the stress concentration of welding points is more apparent and the stress peak value of joint increases. From the distribution of stress, it can be seen, when the distance L from the peeling weldbonded joint to the center of welding point is 2.5cm, all the distribution of stress will show the tensile stress which is similar to the common peeling joint.

Figure 6 depicts the influence of glue-welding combination on stress distribution in Weldbonding joint under bending load. It can be seen from the figure that as to the Weldbonding joints under peeling stress, the reinforcement of the glue-welding combination is relied on the adhesiveness between the glue and the welding point. Disconnect the glue layer from the welding point to disintegrate the glue-welding combination, leaving the glue layer barely loaded and the stress concentration in the welding point becomes very significant and the stress peak of the joint increases drastically, with the bearing capacity and rigidity of the reinforced joint drops considerably. Thus the adhesion quality of the glue-welding structure must be guaranteed. The elastic modulus of the epoxy glue is approximately 1/25 of that of the welding point. The stresses in the glue and the welding spot varies significantly in compatible deformations, as in ordinary joint with the glue layer contacting the welding spot, when the stress in the welding spot reaches 84.83 Mpa, the maximum stress of the epoxy glue only reaches 6.53 Mpa which is unfavorable for the epoxy glue to perform its high strength. Therefore, the composition of the existing epoxy glue shall be modified; also shall new approaches be probed in order to enhance the elastic modulus of the epoxy glue, e.g., to develop new additives to improve the performance of the glue, in order to excavate its potential high strength.

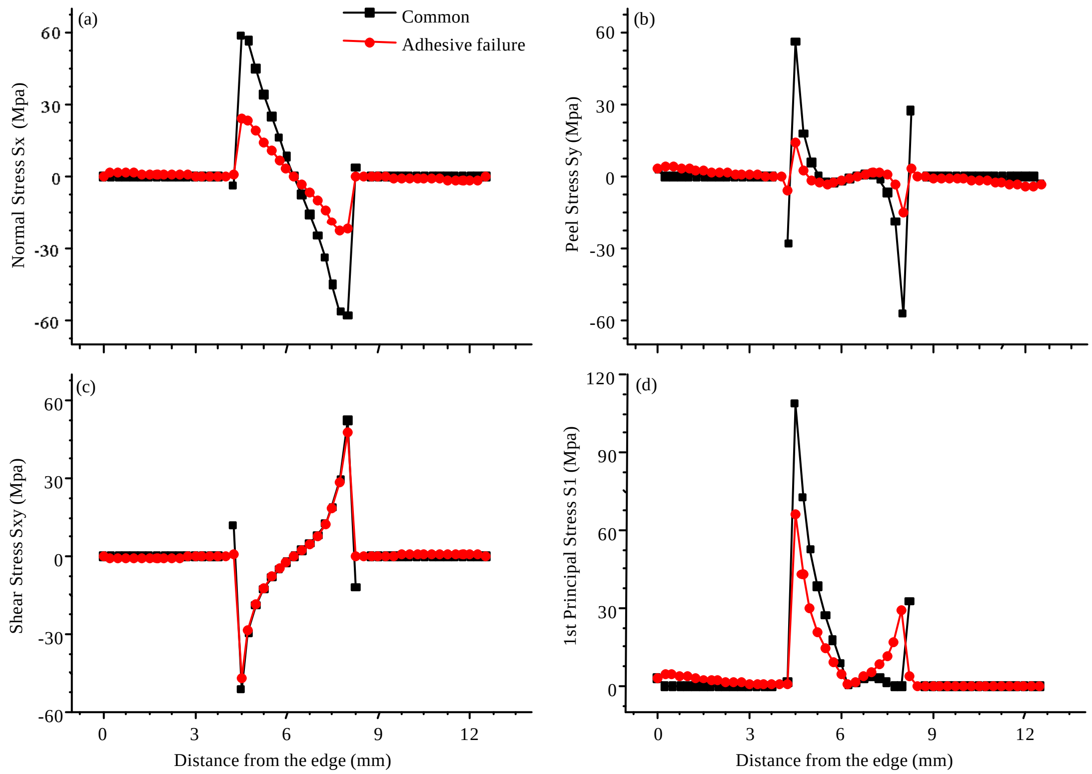

Fig. 6(a-d): Influences of glue-welding combination on stress distribution in Weldbonding joint under bending load

CONCLUSION

This article uses the elastoplastic finite element method to analyze the combination effect influence of weldbonding joint, through the analysis of stress distribution in the middle of adhesive layers; the following conclusions can be obtained:

- It can be seen from paper that as to the Weldbonding joints under peeling load; the reinforcement of the glue-welding combination is relied on the adhesiveness between the glue and the welding point. Disconnect the glue layer from the welding point to disintegrate the glue-welding combination, leaving the glue layer barely loaded and the stress concentration in the welding point becomes very significant and the stress peak of the joint increases drastically, with the bearing capacity and rigidity of the reinforced joint drops considerably. Therefore, adhesion quality is key to the Weldbonding joint under peeling load and must be guaranteed
- It can be seen from paper that as to the Weldbonding joints under bending load; the reinforcement of the glue-welding combination is relied on the adhesiveness between the glue and the welding point. Disconnect the glue layer from the welding point to disintegrate the glue-welding combination, leaving the glue layer barely loaded and the stress concentration in the welding point becomes very significant and the stress peak of the joint increases drastically, with the bearing capacity and rigidity of the reinforced joint drops considerably. Thus the adhesion quality of the glue-welding structure must be guaranteed
- Therefore, the composition of the existing epoxy glue shall be modified; also shall new approaches be probed in order to enhance the elastic modulus of the epoxy glue, e.g. to develop new additives to improve the performance of the glue, in order to excavate its potential high strength

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