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Influencing Factors on Stress Distribution of Weldbonding Joint Under Bending Load

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Abstract: The finite element method was used to study the Influencing Factors on Stress Distribution of Weldbonding Joint under Bending Load. The results show that after welding-reinforced with welding spots, the initial point of compromise is shifted from the end of the glue layer to the connection of the glue layer with the welding spots, which means the overall capacity of the joint has been enhanced, since the yield strength of the welding spots is far greater than that of the glue layer. This suggests that the compatible deformation of the welding spot and the glues under bending load will be improved with higher elastic modulus of the glues. As the thickness of the glue increases, the crushing stress on the left part decreases gradually along with the tensile stress on the right, which also helps to shape the stress distribution in the joint more evenly.

Key words: Bending load, elastic modulus, stress distribution, glue thickness

INTRODUCTION

Weldbonding is becoming an interesting alternative to spot welding in light weight car body design for high strength steels. Weldbonding has a potential for increased fatigue endurance and increased stiffness of the joints and thus for the full body. The weldbonding process of Effect of Spot Pitch on Stress Weldbonded Joints has been studied e.g., Chang *et al*. (2000). Numerical and experimental methods were employed to investigate the effect of the spot pitch on the stress and strain distribution and the joint strength. Results show that when improving spot pitch in weld bonded joints with high elastic modulus adhesives, stresses in weld spot zone are decreased while stresses and strains at edges of overlap region are increased slightly. For the joints with low elastic modulus adhesives, both stress concentration degree at the weld spot and the shear strain at edges of overlap region are increased with the spot pitch increasing. Therefore, fracture strengths of the adhesive layers in both types of joints would decreased with the increase of the spot pitch.

Of special interest to car design is the usage of structural adhesives like epoxy. It has been shown in several publications (Hildebrand and Fathi, 2000; Wang *et al*., 1995). The authors (Zheng *et al*., 2009) think there is no significant effect of whether the nugget exists or not on the peak stress of joint, but it will help improve the quality of bonding joints. the study show that the nugget exists will help improve the quality of bonding joints. Adhesive thickness has great influence on the stress distribution of nugget. Decreasing thickness of adhesive may cause the peak stress increase. The peak stress of nugget is from 10.2-21.6 Mpa when the adhesive thickness is from 0.1-0.4 mm. Therefore, the strength of joint can be improved when the adhesive thickness is thicker, the location of nugget is in the front of joint and the nugget is the main loading bear. Location of the nugget had a great impact on the stress distribution of weld-bonded joint; it changed the joint's model of load-bearing. When the nugget is in the front of joint, the model of load-bearing is mainly in the nugget.

STRIP MODEL ASSUMES

The bending samples are made according to the national standard GB 7124-86 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,

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Table 1: Mechanical properties of materials

Materials	Modulus of elasticity (E/Gpa)	Poisson's ratio (V)	Yield strength (σ_y/Mpa)	Hardening modulus (E_t/Mpa)
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

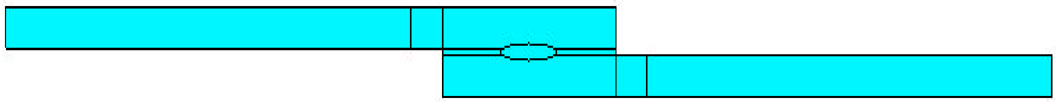

Fig. 1: Bending sample and welding spot positions

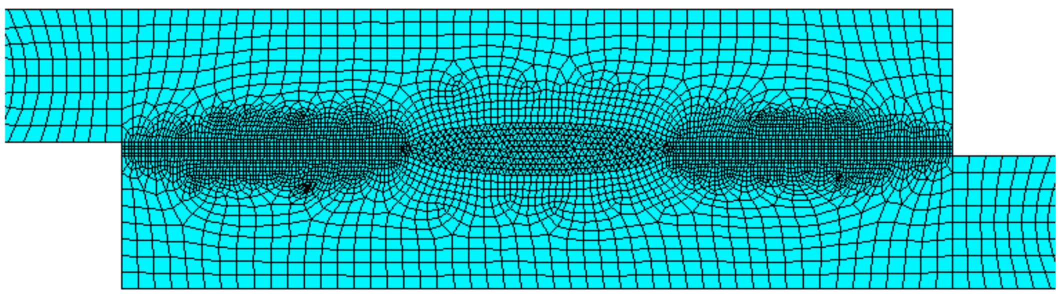

Fig. 2: Lapping area and meshed welding spots of bending sample

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. 1. 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 VonMises 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.

RESULTS AND DISCUSSION

Influences of the nugget exists on stress distribution in Joint under bending load: "Common" refers to the ordinary bended joints without welding spot, while "Strength" refers to bending joints welding-reinforced by welding spot (Fig. 2).

Under three-spot bending load, the common glued joint has its stress peak emerged in both end of the overlapped area while the welding-reinforced joint has its stress peak in the welding spots. In ordinary circumstances, the compromise of the glue layer starts with the breaching at the end of the overlapped parts. As shown in Fig. 3, after welding-reinforced with welding spots, the initial point of compromise is shifted from the end of the glue layer to the connection of the glue layer with the welding spots, which means the overall capacity of the joint has been enhanced, since the yield strength of the welding spots is far greater than that of the glue layer.

Influences of elastic modulus on stress distribution in weldbonding joint under bending load: Figure 4 shows the influences of elastic modulus on stress distribution of glued joint with welding spots under bending stress. It can be seen from the figure that the stress peak value around the welding spots increases along with the increasing elastic modulus. As observed from the stress distribution, the elastic modulus poses smaller influences on positive stress SX and peeling stress SY, comparing with its influence on shearing stress SXY, which has its stress peak increased for approximately 210%, from 15.41 Mpa under the elastic modulus of 2875-47.79 Mpa under the elastic modulus of 50 Mpa, with the peak stress emerged in different locations, a result to the opposite of its influence on simple overlapped joint under bending load, which suggests that the compatible deformation of the welding spot and the glues under bending load will be improved with higher elastic modulus of the glues.

Influences of the thickness of the glue layer on stress distribution in weldbonding joint under bending load: It

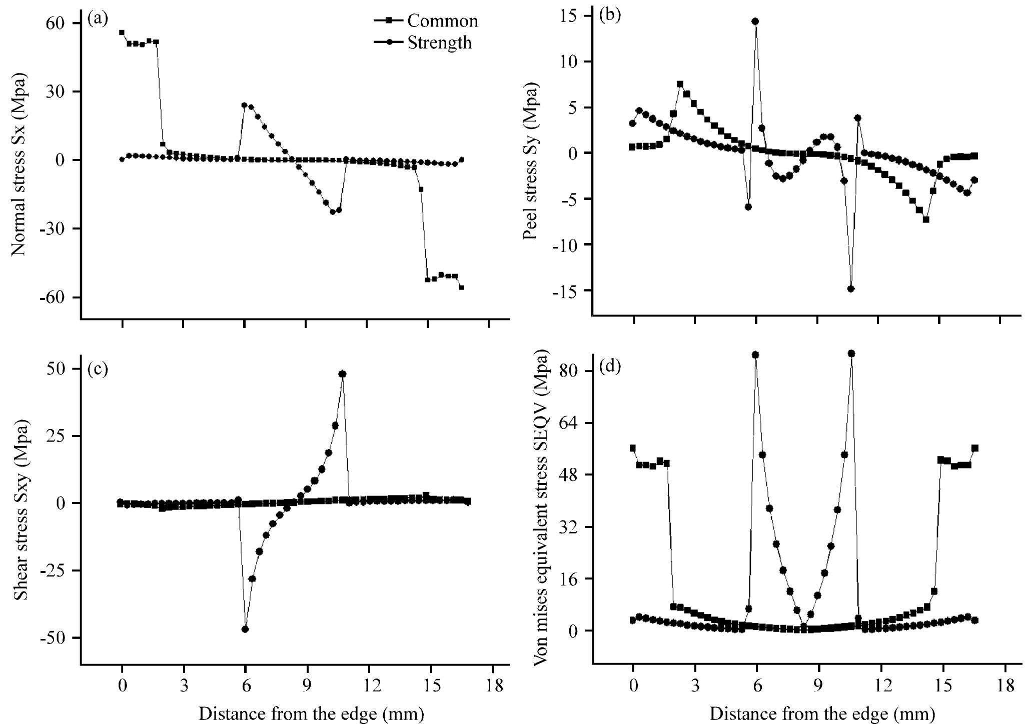

Fig. 3(a-d): Influence with and without welding spots on stress distribution in glued joint under bending load

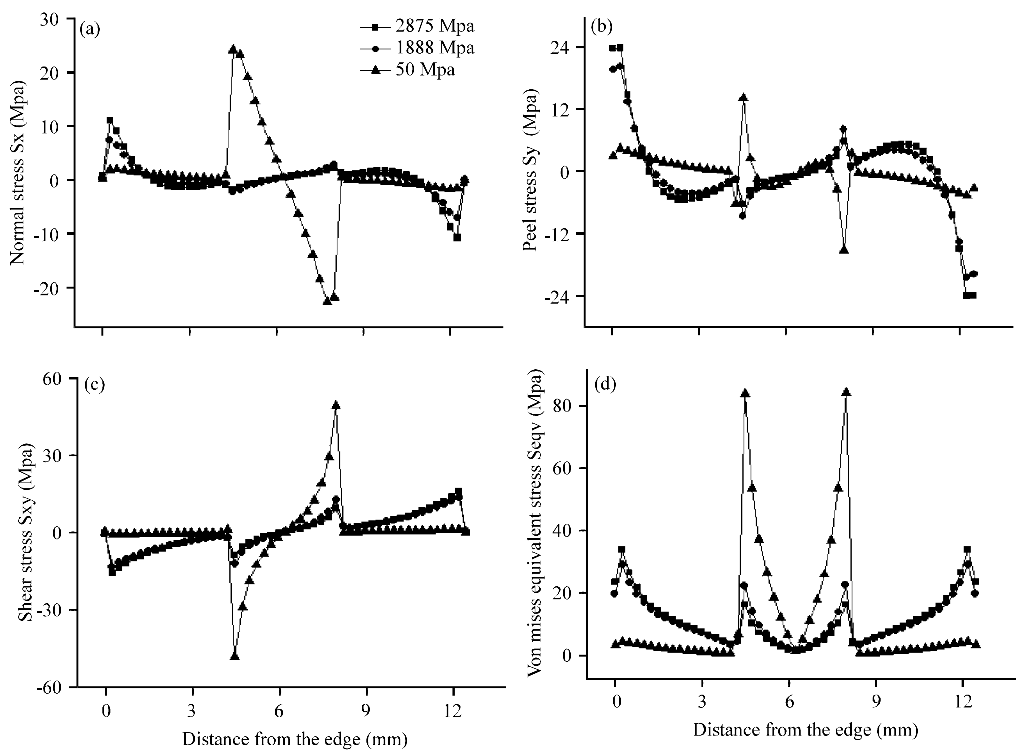

Fig. 4(a-d): Influences of elastic modulus on stress distribution in glued joint with welding spots under bending stress

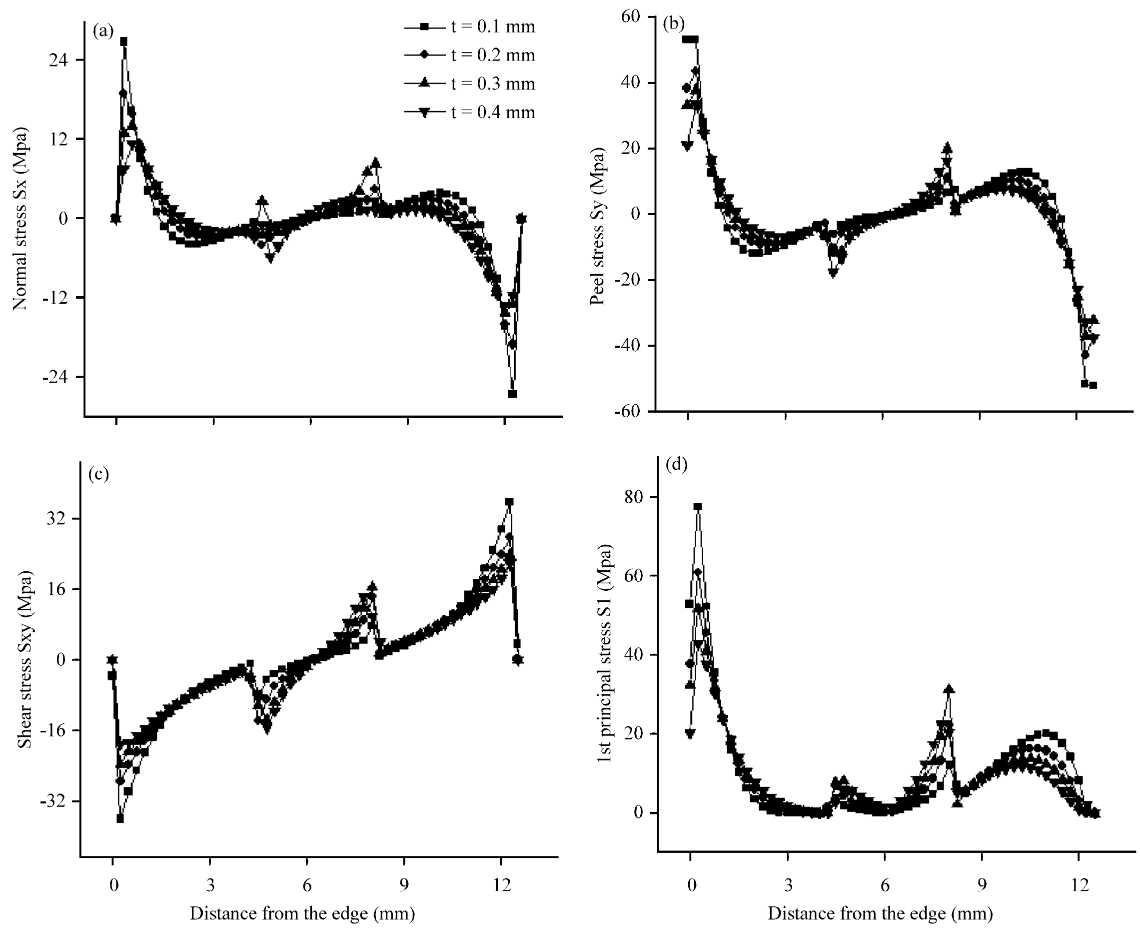

Fig. 5(a-d): Influence of glue thickness on stress distribution in weldbonding joint under bending load

can be concluded from the influence of elastic modulus on stress distribution in Weldbonding Joint under bending load, as shown in Fig. 4, that the compatible deformation of the welding spot and the glues under bending load will be improved with higher elastic modulus of the glues and the peak stress of the glue layer will increase along with. In this part, the epoxy glue is introduced into the discussion of the influence of glue thickness on stress distribution of welding-reinforced joint under bending load, with the characteristics of the material shown in Fig. 1. The thickness of the glue layer is shifted from t = 0.1 mm, t = 0.2 mm, t = 0.3-0.4 mm.

Under three-spot bending stress, the stress distribution and stress peak in the Weldbonding Joint changes along with the increased thickness of the glue layer. Take the 1st Principal Stress S1 for example, as shown in Fig. 5, which the peak stress decreases for approximately 33.24%, from 77.67 Mpa with the glue thickness of 0.1 mm to 44.27 Mpa with the glue thickness of 0.4 mm. The distribution pattern of positive stress SX and peeling stress SY suggests a positive stress on the left part of the overlapping area (tensile stress) and a negative stress on the right (crushing stress); as the thickness of the glue increases, the tensile stress on the right side of the joint decreases gradually, which is favorable for the capacity of the joint and the crushing stress on the left side also decreases gradually, which results in a more evenly distributed stress pattern in the joint. The distribution pattern of shearing stress SXY shows a positive stress (crushing stress) on the left part of the overlapped area and a negative stress (tensile stress) on the right; as the thickness of the glue increases, the crushing stress on the left part decreases gradually along with the tensile stress on the right, which also helps to shape the stress distribution in the joint more evenly.

CONCLUSION

The finite element method was used to study the Influencing Factors on Stress Distribution of

Weldbonding Joint under Bending Load. The results show that after welding-reinforced with welding spots, the initial point of compromise is shifted from the end of the glue layer to the connection of the glue layer with the welding spots, which means the overall capacity of the joint has been enhanced, since the yield strength of the welding spots is far greater than that of the glue layer. This suggests that the compatible deformation of the welding spot and the glues under bending load will be improved with higher elastic modulus of the glues. As the thickness of the glue increases, the crushing stress on the left part decreases gradually along with the tensile stress on the right, which also helps to shape the stress distribution in the joint more evenly.

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