Evaluation of Residual Stress in SPR Joint by Neutron Diffraction

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Materials Science

Introduction

Self-piecing riveted SPR joints have excellent mechanical properties and high fatigue strength, and have been increasingly applied by automobile manufacturers in vehicle body assembly. However, the 3D residual stress field in a mixed metal SPR joint, as a result of large local plastic deformation and cutting of material that occurs during the riveting process, has not been experimentally studied before. Since residual stress usually impacts greatly fatigue life of base material or joints, introducing variation of orders of magnitude, fatigue life prediction of SPR joints is difficult without a thorough understanding of the size and distribution of residual stress.

Experimental procedure

Two typical combinations of joints, including 2.5mm 6111T4 + 2.4mm HSLA340 and 2.5mm 6111T4 + 2.5mm 6111T4 were investigated. Neutron diffraction experiments were performed on strain-scanning diffractometer L3. A monochromatic beam (1.55Å) was used, and the Fe (211) and Al (311) diffracting plane were chosen for the investigation. A gauge volume of 0.75×0.75×4mm was used in order to achieve a good compromise between spatial resolution and experimental counting time. A stress free lattice was used for calculation of micro-strain.

Result

See appendix for brief results.

Summary

The stress profile of SPR could be determined by neutron diffraction, and the magnitude and variation of residual stresses indicates that significant residual stress fields exist around joint. Neutron diffraction could be used for validation of riveting process simulation. Good agreement is found between the simulation and the neutron data.

A pattern of residual stress field might have already developed in original rolled sheets before riveting process. Thus, the reference point of measured stress should be carefully selected in application. Further measurements are suggested to get more accurate reference points at a remote region far away from riveting affected zone.

Figures

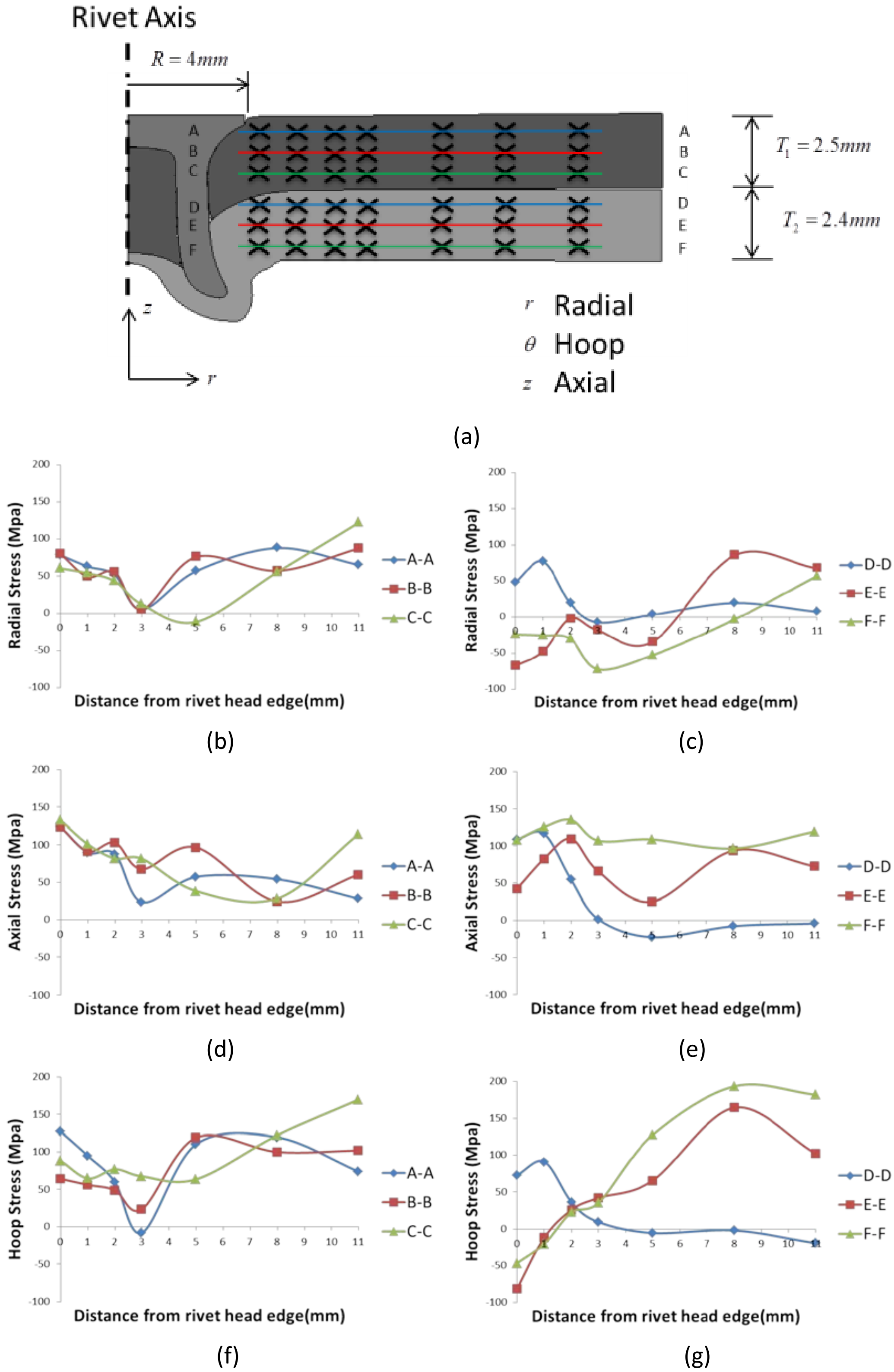

Figure 1. (a)Measurement points of residual stress on half section of joint of 2.5mm 6111T4 + 2.4mm HSLA340, (b) Stresses in radial direction of upper sheet, (c) Stresses in radial direction of lower sheet, (d) Stresses in axial direction of upper sheet, (e) Stresses in axial direction of lower sheet, (f) Stresses in hoop direction of upper sheet, (g) Stresses in hoop direction of lower sheet.

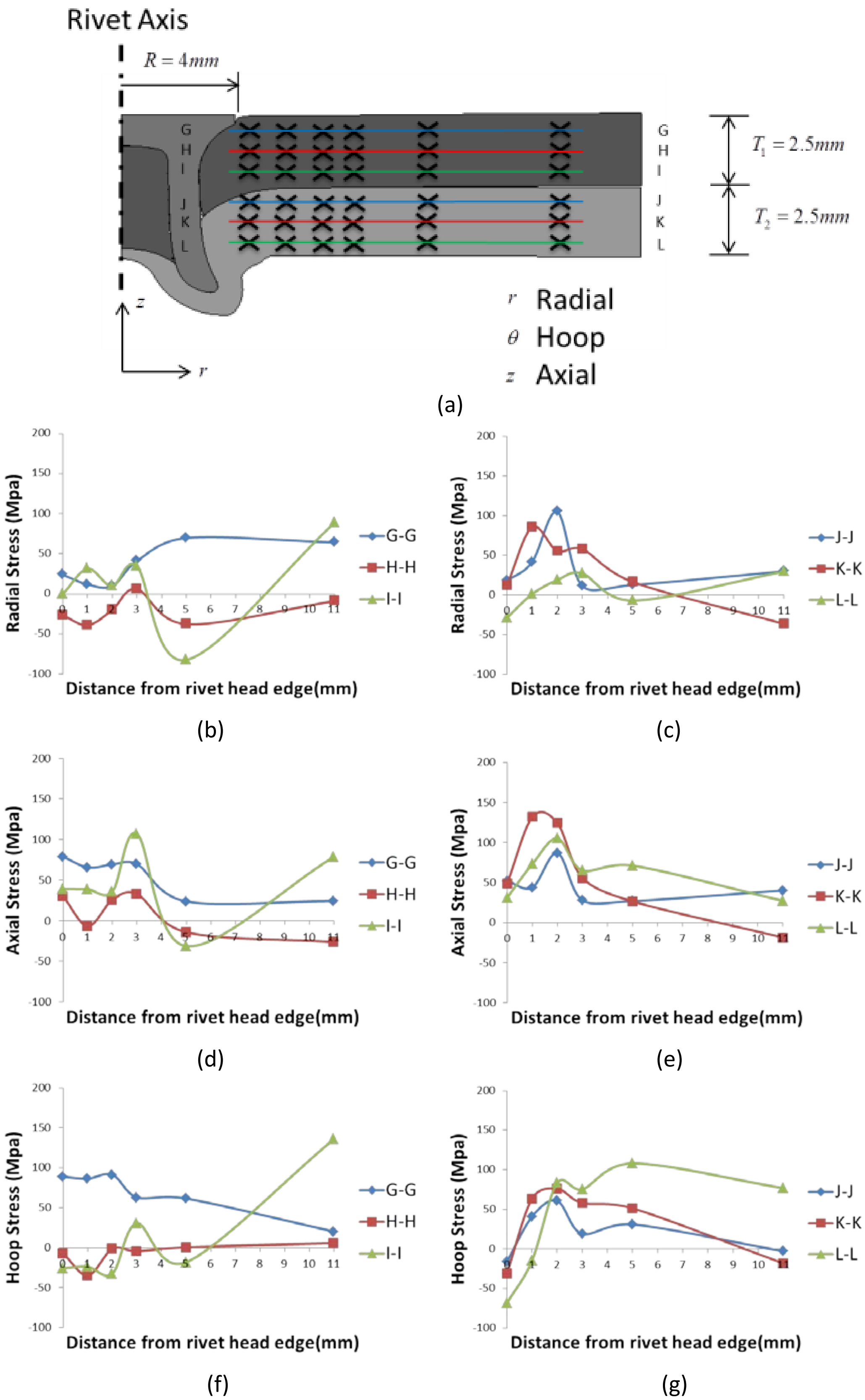

Figure 2. (a) Measurement points of residual stress on half section of joint of 2.5mm 6111T4 + 2.5mm 6111T4, (b) Stresses in radial direction of upper sheet, (c) Stresses in radial direction of lower sheet, (d) Stresses in axial direction of upper sheet, (e) Stresses in axial direction of lower sheet, (f) Stresses in hoop direction of upper sheet, (g) Stresses in hoop direction of lower sheet

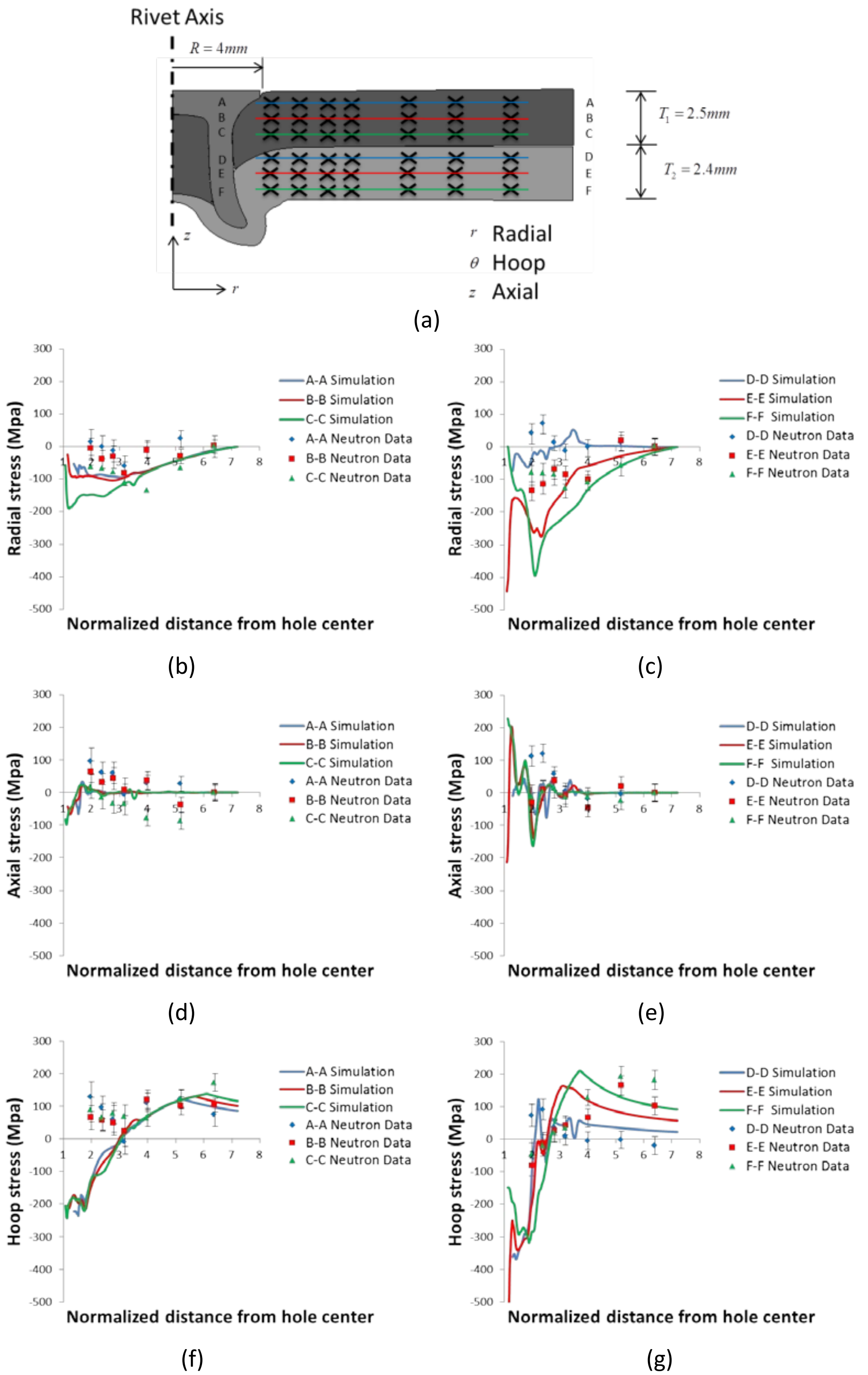

Figure 3. (a)Measurement points in the test and scanning lines in LS-dyna of residual stress on half section of joint of 2.5mm 6111T4 + 2.5mm 6111T4, (b) Stresses in radial direction of upper sheet*, (c) Stresses in radial direction of lower sheet*, (d) Stresses in axial direction of upper sheet*, (e) Stresses in axial direction of lower sheet*, (f) Stresses in hoop direction of upper sheet, (g) Stresses in hoop direction of lower sheet. *Since roll forming process of sheet is not considered in riveting process simulation, radial and axial stress from neutron diffraction is shifted to zero at remote point for comparison between simulation and test.