MODELING OF SOLIDIFICATION IN RESISTANCE SPOT WELDING

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Abstract: *In the present study a comprehensive numerical study has been conducted to simulate the resistance spot welding process. The phase- field method is employed to model the phase change during the melting and solidification of the material. By this way, the martensitic properties are assigned at the nugget and heat affected zone. As a result of this modelling the residual stress at the heat affected zone is attained and shows maximum value on the heat affected zone.*

Keywords: RESISTANCE SPOT WELDING, RESIDUAL STRESS, NUGGET

1. Introduction

Resistance spot welding is a common technique to join the sheet metals in automotive industry [1]. Since the welding method is a thermal process, estimation of the residual stresses and consequently the fatigue of the joint need to analyze the phase change during the melting and solidification of the sheet parts. Available data in the literature reveals that a hard martensitic microstructure in nugget and heat affected zone around the nugget appear after the solidification of the joint [2,3]. In the present study, a comprehensive numerical model including the phase change is introduced to capture these transformations during the welding.

2. Numerical Model

In the resistance spot welding process, the electrical filed passes through the two electrodes which hold two metal sheets together by applying a mechanical force. The resulted resistance from the applied electrical field generates heat to increase temperature in the electrodes and sheets. Some pieces of the metal sheets are melted and joined together. During the cooling of the pieces the molten metal is solidified. But the specifications of the metal at the nugget (solidified metal) is different from the row material. It affects the mechanical properties of the welding parts such as the distribution of the residual stresses.

The governing equations for electrical, thermal and mechanical fields in cylindrical coordinate are

$$\begin{cases} \nabla \cdot J = Q_{j,v} \\ J = \sigma E + J_e \\ E = -\nabla V \end{cases} \quad (1)$$

$$\begin{cases} \rho C_p \dfrac{\partial T}{\partial t} + \rho C_p u \cdot \nabla T + \nabla \cdot q = Q + Q_q \\ q = -k \nabla T \end{cases} \quad (2)$$

$$\begin{cases} \nabla \cdot FS + Fv = 0 \\ F = I + \nabla u \end{cases} \quad (3)$$

Boundary conditions are depicts in Table 1.

Welding Time	80 ms
Holding Time	480 ms
Electrode Force	4000 N
Applied Current	7 kA
Material of Sheets	AISI 316L
Materila of Electrodes	Cu-Cr Alloy

The phase-field method is used to model the two- phase (liquid and solid) and capturing the interface. During the solidification the mechanical properties of the material are replaced by martensitic properties. Figs. 1,2 illustrate the phase transition and von Mises stress distribution at the end of the welding time, respectively.

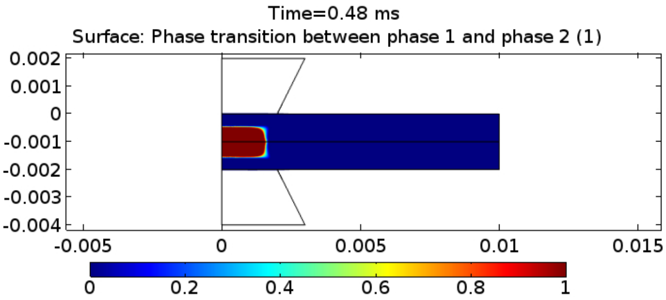

Fig. 1 Phase transition between solid (base metal) and liquid (molten metal)

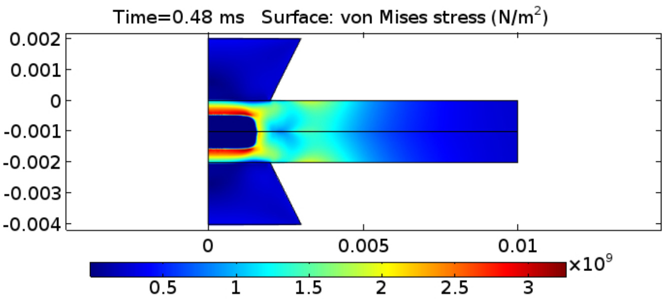

Fig. 2 Distribution of von mises stress at the end of welding time

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