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Finite Element Analysis of Resistance Spot Weld Uses Transient Thermal Distribution of Automobile Component

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Abstract : Spot welds are used extensively in the automotive industry to join panels, and car bodies contain many thousands of spot welds. Different finite elements method of spot welds have been created for various types of analysis. When structures with many spot welds are analysed, these detailed models have too many degrees of freedom to be used in practice. Simple models that use few elements must be instead. This work presents the FEA simulation of the RSW process. A 2D axisymmetric FEM model has developed to analyse the transient thermal behaviours of process using ANSYS software.

Keywords: RSW, temperature distribution, FEM automotive structures, transient thermal analysis.

I. Introduction

Electric resistance spot welding has been used for many years in the automotive industry for joining body sheet components, and it is particularly well suited for uncoated, low carbon steel. The effectiveness of the process depends, to a considerable extent, on electrode cap life. Coatings on the steel and other metals (e.g., aluminum) can reduce electrode life. Many factors — thermal, electrical, mechanical and metallurgical — influence electrode cap life. Electrode caps are subject to severe thermal operating conditions and mechanical forces that are responsible for electrode deterioration (e.g., wear, tip contamination, tip mushrooming), which leads to a decline in weld quality and a reduced electrode life. The degradation is particularly acute in spot welding galvanized steel and aluminum alloys, and the correction of such problems during production often necessitates on-line maintenance. In the spot welding process, thermal conditions at the two main interfaces — the faying surface, which is the workpiece/workpiece interface, and the electrode/workpiece interface — are particularly critical. The faying surface temperature affects the size and quality of the welds. Since excessive heating at the electrode/workpiece surface gives rise to cap deterioration, for a long electrode life the temperature should be kept as low as possible, while maintaining a higher temperature at the workpiece faying surfaces. Knowledge of temperature distribution in the electrode cap could be of importance to improved electrode life and for the maintenance of spot weld quality, e.g., by suggesting changes in the electrode design. Temperatures adjacent to the tip surface have been measured but because of experimental limitations associated with the physical size of the thermocouples used in the determinations, the temperature values measured were not those exactly on the surface. Since the thermal gradients near the surface are very large the surface temperatures can be determined only by extrapolation. Numerical methods have been employed to predict cap temperature distributions. However, these models did not consider the presence of water in the cooling chamber of the tip, and the heat loss of the electrode to the coolant either was estimated or determined experimentally. The object of this investigation was to determine the temperature distribution (in particular, the maximum tip surface temperature) without relying upon heat loss test data. In heat transfer analysis, the energy equation must be coupled with the equations of continuity and motion to describe the process of heat conduction and convection. In classical heat transfer analysis, convection has been considered only as one type of thermal boundary condition to be applied at the surface of a conducting solid. This amounts to decoupling the energy equation from those of continuity and motion. In this approach, since convection is given at the boundary, only the energy equation is required. However, values for the convection coefficients required can vary by K. S. YEUNG and P. H. THORNTON are with Scientific Research Laboratories, Ford Motor Company, Dearborn, Mich.

II. Objectives

The objectives of this project work were as follows:

Objective of this analysis is to understand the physics process and to develop a predictive tool for analysis.

- To study the effect of parameters on resistance spot weld process.
- In addition to that, the aim of this thesis is also to field a relationship between parameter and thermo-elastic-plastic response.

Elements are used solid 90:-

SOLID90 is a higher order version of the 3-D eight node thermal element (SOLID70). The element has 20 nodes with a single degree of freedom, temperature, at each node. The 20-node elements have compatible temperature shapes and are well suited to model curved boundaries. The 20-node thermal element is applicable to a 3-D, steady-state or transient thermal analysis. Orthotropic material directions correspond to the element coordinate directions.

Materials: - copper electrode and MS,

Properties are required: - thermal conductivity, resistivity, and young’s modulus, coefficient of thermal expansion, yield stress, specific heat and contact resistivity.

Temp range:-21 -1204 degrees Celsius

Electric current= 50 Hz sine wave AC

Loading condition: -

Current 10KA applied for 200ms.The current is imposed as an electric load on the top surface of upper electrode. To simulate the cooling process of welding, the hold time is taken as 60ms.A force 3000N is applied on the upper electrode which is equivalent to the pneumatic pressure applied on the sheets**.** The most important property in the simulation of RSW process is the contact resistivity of faying surface. to simply the problem, the contact resistivity is considered as a function of temperature.

Boundary condition:-

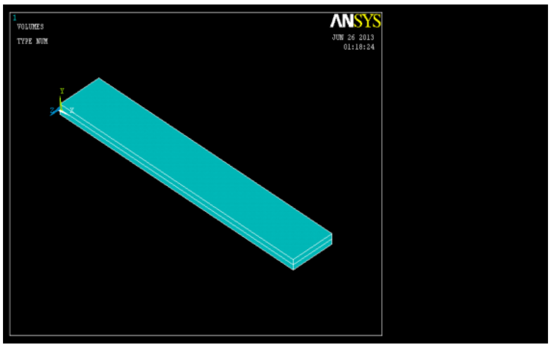
The boundary condition imposed for the analysis the upper face of top electrode and lower face of bottom electrode are considered in x & y direction. A voltage difference is applied across the top face of upper electrode and bottom face of lower electrode. The convention coefficient of air (21 $w/m^2 0C$) is applied on faces of electrode and sheet which are open to environment. The convection coefficient of water (300 $w/m^2\ ^0C$) is applied on the inner face of electrode which are in contact with in circulating water with initial temp of 24 ^0c.

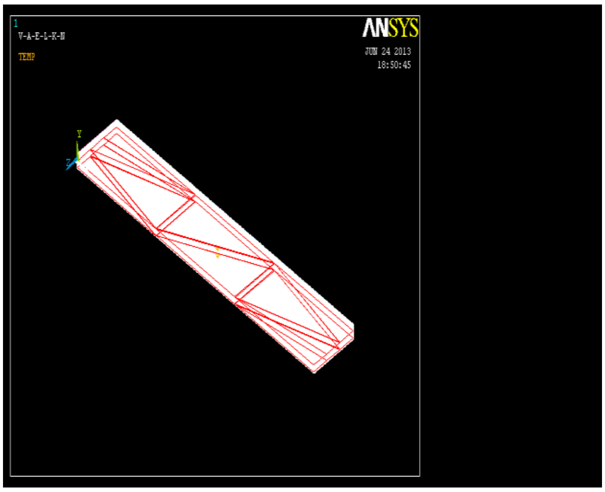
Transient thermal analysis:-

Given data:-

Propertie	0 C	100C	1450 C
Youngs modulus	314 MPa	349 MPa	1.29 MPa
Poisons ration	0.33	0.33	0.33
Thermal conductiv	51.9w/m 0K	51.1 w/m 0K	26 w/m
Thermal coefficien t	10e-6 / C	11e-6 /C	15e-6 /C

Mesh model of RSW:-

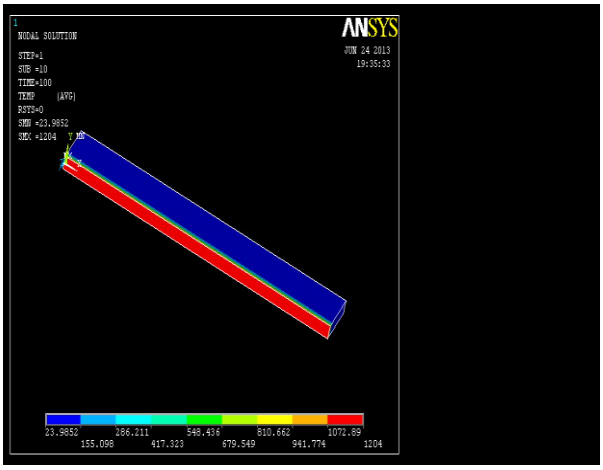




Result:-

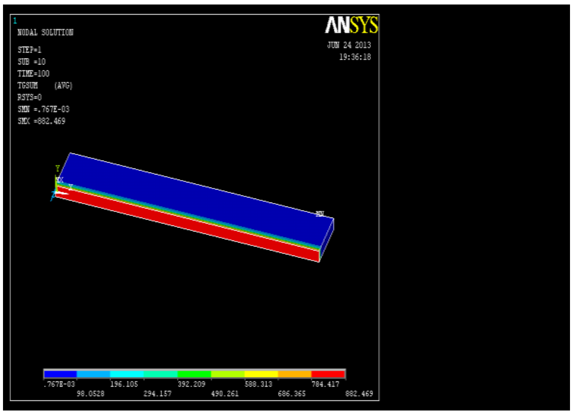
Transients' thermal analysis:-(temp apply on side)

Temperature distribution:



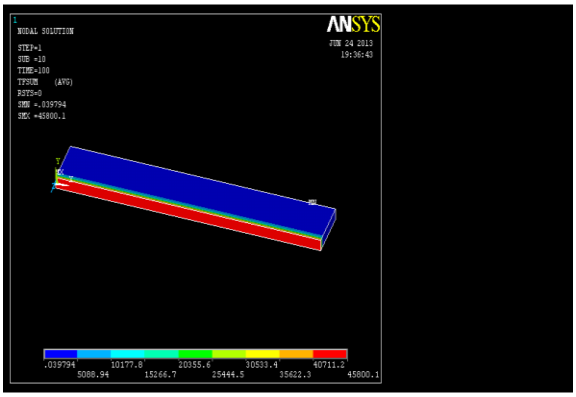
In above analysis fig shows the temp distribution on spot weld range of 23.9852 ^{0} C to 1204^{0}C.

Temp Stresses On Plate:



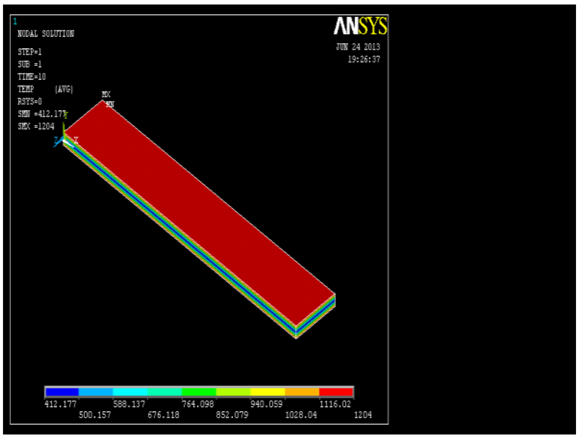
In this analysis fig shows the temp stress on spot weld plate on the higher temp of electrode i.e. 882.469 Pa

Thermal flux:



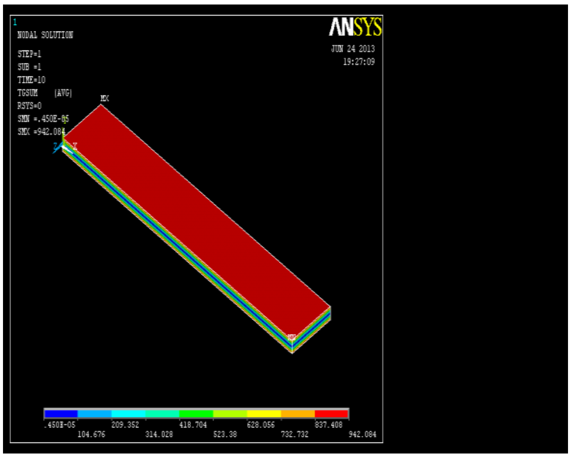
In this analysis fig shows the thermal flux on spot weld plate on the higher temp of electrode i.e. 45800.1. Transients' thermal analysis:- (temp apply on upper side)

Temperature distribution:



In above analysis fig shows the temp distribution on spot weld range of 412.177 ^{0} C to 1204^{0}C.

Temp Stresses on Plate:



In this analysis fig shows the temp stress on spot weld plate on the higher temp of electrode i.e. 942.084 Pa

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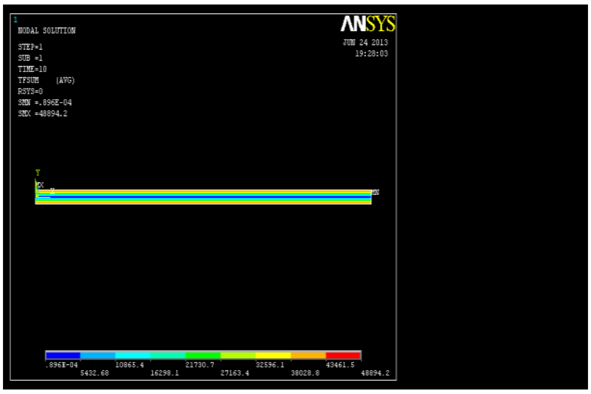
Thermal flux:



In this analysis fig shows the thermal flux on spot weld plate on the higher temp of electrode i.e. 48894.2.

Sr. No.	**Temperature distribution**	**Thermal stresses**	**Thermal flux**
1	**23.9852 ^{0} C to 1204 ^{0}C.**	**882.469 Pa**	**45800.1.**
2	**412.177 ^{0} C to 1204 ^{0}C.**	**942.084 Pa**	**48894.2.**

III. CONCLUSIONS

- In the above problem, we show the temperature distribution of RSW range of 412.177^{0} C to 1204 ^{0}C. Temperature is suitable for spot welds.
- In the above problem, we observe that the thermal stresses of RSW are 942.084 Pa is suitable for spot welds.
- In the above problem, we observe that the thermal flux of RSW is 48894.2 is suitable for spot welds.
- In transient thermal analysis, we had distributed temperature and respective thermal stresses of RSW (resistance spot welding) for automobile components.

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