Numerical methods in the simulation of resistance welding

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ABSTRACT

Finite element simulation of resistance welding requires coupling between mechanical, thermal and electrical models. This paper presents the numerical models and their couplings that are utilized in the computer program SORPAS® [1,2], which is currently recognized as the leading software for resistance welding in the automotive and electronic industries. A mechanical model based on the irreducible flow formulation is utilized to simulate plastic deformation and the resulting distribution of stress, a thermal model based on transient heat transfer is used to determine the distribution of temperature, and a steady-state electrical model is employed to calculate the distribution of electrical potential and current density. From a resistance welding point of view, the most essential coupling between the above mentioned models is the heat generation by electrical current due to Joule heating.

The interaction between multiple objects is another critical feature of the numerical simulation of resistance welding because it influences the contact area and the distribution of contact pressure. The electrical and thermal contact resistances are calculated at a given temperature based on the mechanical interaction between objects, and the electrical contact resistance plays an important role in the heat generation, thereby influencing the location, shape and size of the weld nugget.

Microstructure is an important measure of quality due to the welding temperatures and rapid cooling through the electrodes during solidification of the weld nugget. The numerical prediction of the resulting phases and hardness is based on the temperature history and cooling rates compared to critical cooling rates obtained from continuous cooling transformation (CCT) phase diagrams.

The joint strength is another measure of quality and raises the need of coupling the above mentioned models with damage modelling. SORPAS® performs damage modelling by means of a porous based model that accounts for the creation, growth and coalescence of voids in a homogeneous sense over each element.

The numerical simulation of resistance welding is illustrated by means of a selected number of test cases with focus on the accuracy, reliability and validity of the finite element computer program SORPAS®.

REFERENCES

[1] W. Zhang, “Design and implementation of software for resistance welding process simulations”, *Trans. J. Mater. Manuf.*, Vol. **112**(5), pp. 556–564, (2003).

[2] C.V. Nielsen, W. Zhang, L.M. Alves, N. Bay and P.A.F. Martins, *Modeling of Thermo-Electro-Mechanical Manufacturing Processes with Applications in Metal Forming and Resistance Welding*, Springer, 2012.