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Multiphysics simulation of welding process

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ABSTRACT

Heat transfer during welding can strongly affect phase transformations and thus the metallurgical structure and mechanical properties of the weld. In the fusion welding process, fluid flow in the melt pool is responsible for the melt pool shape and temperature distribution in the workpiece. These factors have a close relationship to the resulting material structure and properties, such as microstructure, hardness and surface roughness. The melt flow is influenced by surface tension gradients at the free surface (Marangoni effect) and thermal gradients in the melt pool (natural convection).

The different phenomena interfering in the melt pool have been identified and modeled in the in house CFD solver (Argo). A single domain approach with an enthalpy-porosity formulation has been used [1]. This formulation allows the use of a single set of equations and boundary conditions for liquid, solid and mushy zone. The model takes into account the change of physical parameters between liquid and solid phase, latent heat of fusion absorption during melting and release when solidification takes place. Two different driving forces are considered. Natural convection is modeled using the Boussinesq approximation for incompressible flows. The variation of surface tension with temperature on the free surfaces of the melt pool gives rise to shear stress on these surfaces (Marangoni effect); this effect is modeled by introducing a temperature dependend surface shear source term. The influence of each of the forces on the final melt pool shape has been studied.

Simulation of the Electron Beam Welding process have been performed with the model described above. It appears that the natural convection term only has a small effect on the weld pool shape; yet the Marangoni effect seems to be the predominant phenomenon, as the vortices formed near the top and bottom surface significantly contribute to the heat redistribution in the pool.

The calculated weld shape has been compared to a transverse macrosection of a electron beam welded joint. The simulated melt pool shape presents a spreading of the top and bottom part of the melt pool of the same order of magnitude as in the experimental case.

The aim of this work is to used the predicted temperature field as input for the in house finite element code Morfeo to predict distorsions and residual stresses after welding.

REFERENCES

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