# A One Way Coupled Thermo-Mechanical Model to Determine Residual Stresses and Deformations in butt welding of Two ASTM A36 Steel Plates

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## ABSTRACT

To simulate the gas metal arc welding (GMAW) process in two ASTM A36 steel plates a finite element numerical model was developed, to obtain the corresponding residual stresses and deformations. The welding process was simulated as a one way coupled thermo-structural problem, considering that the structural field has very little influence in the thermal field, which is widely accepted in the specialized literature. To solve the thermal field, a nonlinear transient problem was created using finite second order elements that have temperature as the only degree of freedom in their nodes. The thermal properties of material were defined as a function of temperature and a combined convection-radiation coefficient was used as a boundary condition. The double ellipsoid model presented by Goldak was used to simulate the heat source and its dimensions were determined from the expressions developed by Christensen. To solve the structural field another nonlinear transient problem was created, considering the same mesh and the same time step of the thermal problem, using finite second order elements that have three displacements as degrees of freedom in their nodes. The mechanical properties of material were defined as a function of temperature, a thermo-elasto-plastic material model was used and the necessary displacement restrictions were used as a boundary condition. The temperature distribution obtained by solving the thermal field at each time step was transferred as a load to the structural problem. In both problems the “birth and death” technique was used to simulate the material deposition, which is implemented in the ANSYS software used in the present study. The activation of “dead” elements of the weld bead in the thermal analysis was performed simultaneously with the passage of the heat source, while in the structural analysis “dead” elements were activated as a function of their temperature. Different activation temperatures of “dead” elements were tested in the structural analysis, obtaining the best results when this temperature takes a value of 80% of material solidification temperature. The model used in this study was validated experimentally, taking as reference the residual displacements in several points of the welded plates. It was verified that there is a good correspondence between numerical and experimental results, with an error of less than 10%.

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