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A COUPLED FLUID/SOLID APPROACH FOR THE NUMERICAL SIMULATION OF WELDING

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The aim of this work is to develop a numerical tool for the simulation of assembly processes at high temperatures, and more specifically the arc welding process, in order to calculate the induced distortions and residual stresses. The modeling of this type of process requires the consideration of the solid and the liquid states of the material as described in the figure 1. Several difficulties are found in this kind of modeling. They remain in the modeling of the molten pool and the fluid flows, the inclusion of the free surface, the transition between the different states, and the modeling of the heat affected zone.

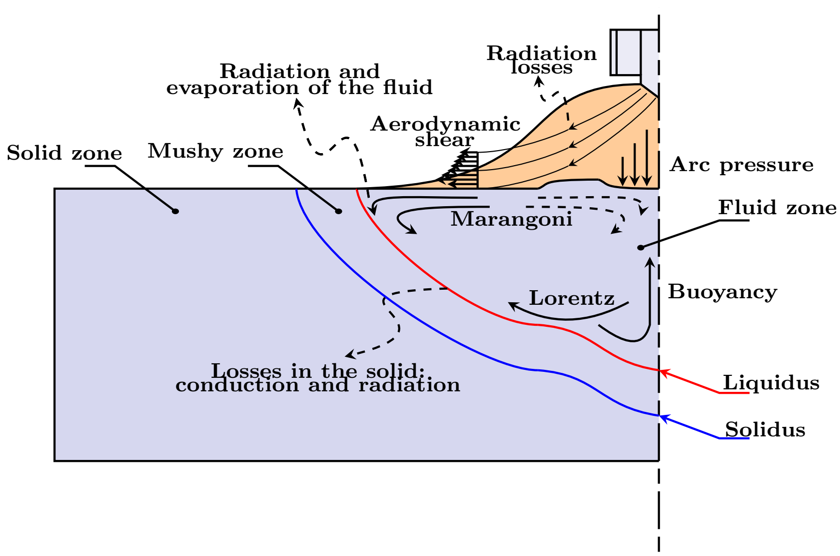

Figure 1: *Schematisation of the material states and the fluid flows during welding process*

For the elements that have a temperature higher than the liquidus temperature, we consider a newtonian fluid, dilatable and thermally compressible. This zone is called the molten pool and is dominated by multiple flows having a hard impact on its morphology. We consider the surface tension effect related to the strong thermal gradient "Marangoni effect" in the one hand and to the curvature of the free surface of the fluid in the second hand. The buoyancy forces related to the variation of the density is also taken into account. The problem is governed by the energy and the Navier-Stokes equations. A temperature/velocity/pressure mixed formulation based on the linear tetrahedron element P1+/P1 [1] is used.

In the solid zone, we consider two different areas. The first one [2] includes the elements that have a temperature lower than the solidus temperature in which we consider an elasto-plastic compressible material obeying to the von Mises criterion. The second one includes the elements that have a temperature lying between the solidus and the liquidus temperature. In this area, we suppose a specific behaviour law [3], able to model the coexistence of the solid and the liquid phases in order to have a continuous transition to the liquid state. The problem is governed by the energy and the momentum equations. A temperature/velocity/pressure mixed formulation based on the linear tetrahedron element P1/P1 and a formulation in large transformation solid mechanics is used.

The coupling of both these states consists in using an arbitrary Lagrangian Eulerian method in which the nodes follow the material in the solid zone but not in the liquid zone. The local integration of the constitutive law is based on a fully implicit algorithm in time combined with a Newton-Raphson type method. These developements are included in a special option of the finite element software SYSWELD® [4].

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