Fluid/Solid coupling for the simulation of welding process

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Welding is a major need for the most manufacturing industries. The large use of welding and the need to improve and better control the welding process ability have led to the development of several numerical simulation approaches, which may provide valuable assistance to study the process's effects on the final parts.

During this process, the material undergoes thermal cycles which lead to state changes (liquid and solid) and fluid flows in weld pool. These fluid flows are related to the strong thermal gradient and caused by the effects of surface tension "Marangoni and curvature effects". This dynamic in weld pool affect the temperature field distribution, the morphology of the molten zone and the generated stress field. Therefore, in order to reproduce as possible the physical phenomena occurring during the welding process, it is very important to take into account the fluid flows in the weld pool during numerical simulation. Add to this, the type of coupling between fluid and solid computations is very important during the numerical simulation. Generally, a low coupling is used to relate those computations. It consists to begin by a complete thermal-fluid simulation of the process, where the fluid flows in weld pool is taken into account. Then, the results of this first simulation are used as input data in a solid-state computation to determine residual stresses and distortions.

The aim of this study is to simulate the welding process by mean of a strong coupling between fluid flows and solid deformation. For this, a 3D numerical model of a hybrid laser/arc welding is developed with SYSWELD® software [2]. At first, results of a single thermal-fluid simulation show a significant effect of fluid flows (Marangoni and curvature effects) on temperature distribution and melt pool size. Indeed, a model within fluid flows shows more cooling rate compared with the model without fluid flows. In a second step, a strong coupling strategy is developed to simulate the thermo-fluid flows and the solid-state stress field at each computing time step. The object is to estimate residual stresses and distortions, in order to obtain final proprieties of welding parts.

[1] T. Sayet, E. Feulvarch, J.B Leblond, J.M Bergheau, Simulation numérique du soudage : Couplage des écoulements dans le bain fondu avec les deformations de la partie solide, (2014).

[2] ESI Group, User manual, (2015).