

Numerical modelling of fluid flow and interface evolution in the process of welding with smoothed particle hydrodynamics and parallel computation

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As part of the project “Modelling of Interface Evolution in Advanced Welding (MintWeld)”, under the Seventh Framework Programme of the EC, the authors have been working on the numerical modelling of welding. Their specific target is to develop a novel and advanced numerical model which is able to predict the evolution of interfaces and accompanying flow of liquid metal in the process of welding.

In the process of welding, the interfaces that separate gas, liquid metal and solid metal move rapidly and significantly, due to strong flow of liquid metal and heat transfer. The evolution of interfaces has a dominant influence on the final mechanical properties of welded joints. In this project, the authors are trying to develop a numerical model which is able to predict the evolution of the interfaces and accompanying fluid flow and heat transfer phenomena which occur during welding. This will significantly help the relevant industry to optimise their welding processes.

Smoothed particle hydrodynamics (SPH) is a meshless Lagrangian method. In SPH, each particle represents a specific mass of fluid which carries fluid information such as position, velocity and temperature. The authors have been employing SPH to develop their numerical model for welding, for the first time, in order to simulate melting and fluid flow during welding processes. In this model melting of the solid parent material, gas-melt two phase flow, heat transfer, and surface tension are all considered. It has been used to study the evolution of the temperature field and fluid flow in the case study of laser spot welding in 2D. The simulation results show a strong influence of the melting process on the flow of liquid metal and a clear influence of the Marangoni flow on the heat transfer is also found.

The numerical simulation with the SPH model of the authors is relatively computationally intensive and hence parallel computation turns out to be essential. The current SPH model for welding has been implemented based on source codes written in-house by the authors in C++ and MPI. Parallel computation, based on coding with MPI, has been used by the authors to improve the computational efficiency. By doing parallel computation with the Stokes cluster of ICHEC, the authors are planning to keep developing their SPH model for welding, including employing arc torch and filler metals in the model, extending the current 2D SPH model to 3D, and improving computational efficiency by doing some more advanced coding with MPI.