SPH simulation of gas arc welding process

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Abstract: The thermofluid behavior of a weld pool during a TIG (tungsten inert gas) welding process is simulated by SPH (smoothed particle hydrodynamics) method, taking into account the phase change of the anode material, free surface movement of the liquid, and four dominant flow-driving forces. Reasonable computational results are obtained, and it is shown that the SPH method is applicable to this kind of phenomena.

Keywords: SPH, TIG Welding, Arc Weld Pool, Surface Tension.

1 Introduction

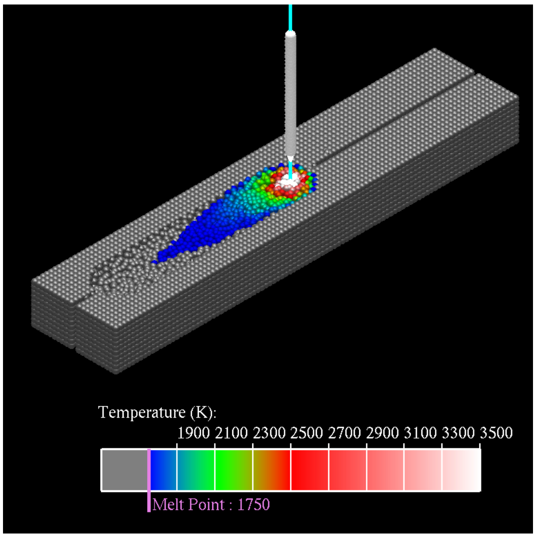
Arc welding is one of the essential technologies that are supporting the heavy industries. However, its technical development is largely based on the empirical knowledge and the skill of engineers in the field, mainly because of the difficulties in experimental measurements. Thus, the phenomena associated with the arc welding are still poorly understood with many unexplained questions even about its basics. Little is known about the flow inside a molten metal puddle, namely the weld pool. The lack of knowledge makes an accurate prediction of state and geometry of arc weld pool impossible, which is necessary in order to control the quality of welding.

Computational simulation is a powerful tool to investigate the weld pool formation. However, a weld pool process is a complex problem of interface physics which involves the effects of surface tension and deformations of a gas-liquid interface and a solid-liquid interface [1], which makes numerical calculations of the molten pool inherently difficult. Solving such a flow field by the grid-based methods is an exhaustive task since a special effort such as a regeneration of the grid is required [2]. Thus, either the high-end technical application of a grid base method or a more reasonable grid less method is demanded for a welding simulation.

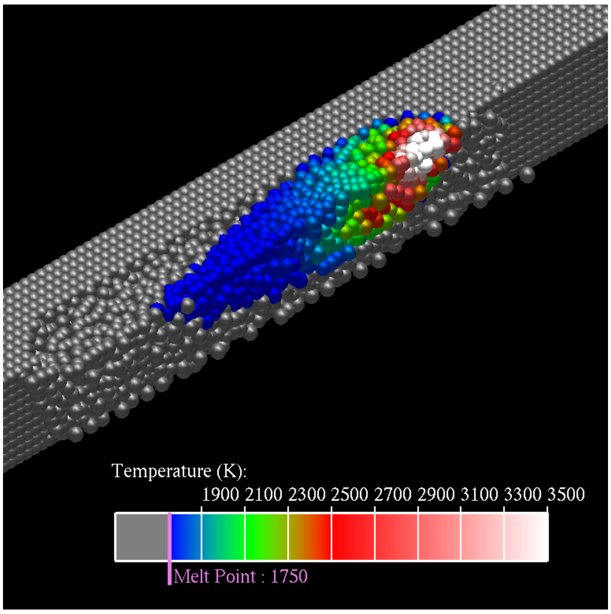
SPH is a Lagrangian particle method that offers some advantages such as the simplicity and flexibility to the complex geometry deformations. In this study, the molten pool convection is simulated by the SPH method.

2 Computational conditions and Results

The target of the computation is an anode metal in the TIG welding system. The shielding gas flowing on the anode surface and electric current in the anode are not analyzed in the present simulation. These factors are counted as steady boundary conditions based on the numerical data provided by Tanaka et al. [3]



(a) Overview



(b) Detailed view of a half domain

Figure 1: Computation of the arc welding process.

The top surface of the anode plate is heated by the shielding gas temperature. The high temperature region of the surface changes to a liquid puddle. The liquid is driven by the four dominant forces: buoyancy, surface tension gradient, Lorentz force, and friction with the gas flow. Thus, a convectional flow is generated. Figure 1 shows the snapshots of the three-dimensional computation of the welding process. The particles are colored by phase and temperature. The gray indicates the solid particles, the magenta is the melting point and other colors represent the temperature of the liquid particles. As shown in Fig. 1, the arc heat source melts the anode material, however the melted region is solidified again later after the heat source passes by. Present computation appears to be successfully simulating the welding process.

3 Conclusion

SPH method was applied to simulate the TIG welding process. The present computation showed that SPH method was capable of simulating a melting-solidifying process of the welding.

References

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