SMOOTHED PARTICLE HYDRODYNAMICS SIMULATION OF THE FRICTION STIR WELDING PROCESS

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Friction stir welding (FSW) is a solid state joining technology highly favorable for hard-to-weld alloys [1]. In contrast to more common fusion welding, the FSW process provides the connection of two-facing workpieces without melting to produce the weld but due to softening and stirring the base material at an elevated temperature. The amount of heat necessary for getting the material into a yielding state is produced by friction between the workpiece and the rotating tool [2].

As a rotating tool moves inside the workpiece, it causes material flow and microstructural evolution hidden from direct observations during the experiments. In turn, to ensure the quality of the welding, those features should be tracked explicitly. Thus, many efforts are spent in modeling FSW using various simulation techniques. Doing so, common grid-based methods like the Finite Element Method face crucial issues to produce an adequate simulation model due to substantial topology changes related to large plastic deformation as the welding process goes on. On the other hand, the Smoothed Particle Hydrodynamics (SPH) method provides a model with freely moving particles as constituents of a continuum allowing to eliminate the mesh distortion [3]. Besides large deformations, FSW is governed by a variety of heat and mechanical interdependent effects. Therefore, the coupled thermo-mechanical simulation is necessary for an accurate representation of the FSW process. Also, the large deformation as a non-linear inelastic material response is accompanied by both hardening and softening as well as it serves as a source of heat supplementary to the heat from friction.

In the present contribution, the SPH within the explicit framework implemented in ABAQUS [4] is used to simulate the FSW process. The SPH model in conjunction with necessary material constitutive laws and combining thermal, mechanical, and contact effects is developed. A case study is presented, to gain a deeper insight into the heat transfer and material stirring phenomena during the friction stir welding process.The simulation of FSW was validated b comparisons with known experimental results and the results of the other simulation technique.

Reference:

[1] Thomas W., Nicholas E., Needham J., Murch M., Temple-Smith P., Dawes C. Friction-stirbutt welding. Great Britain Patent Application No. GB9125978.8, 1991.

[2] Jain R., et al. Friction stir welding: scope and recent development. In:Modern Manufacturing Engineering. Materials Forming, Machining and Tribology, Davim J. (Eds). Springer, Cham, 2015, pp. 179-229.

[3] Lind S.J., Rogers B.D., Stansby P.K. Review of smoothed particle hydrodynamics: towards converged Lagrangian flow modelling. Proc. R. Soc. A.476, pp. 1 – 27, 2020.

[4] ABAQUS User’s Manual. Ver. 2016. Dassault Systèmes Simulia Corp. Providence, RI, USA, 2016.