11th. World Congress on Computational Mechanics (WCCM XI)
5th. European Conference on Computational Mechanics (ECCM V)
6th. European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

3D NUMERICAL SIMULATION OF FRICTION STIR WELDING PROCESSES WITH NON-CYLINDRICAL PIN: COMPARISON OF A FLUID AND A SOLID APPROACH

P. Bussetta[1], N. Dialami[2], R. Boman[1], M. Chiumenti[2], C. Agelet de Saracibar[2], M. Cervera[2] and J.-P. Ponthot[1]

[1] University of Liege, Department of Aerospace & Mechanical Engineering,
Non Linear Computational Mechanics, Building B52/3,
Chemin des Chevreuils, 1; B-4000 Liege, Belgium
e-mail: {P.Bussetta; R.Boman; JP.Ponthot}@ulg.ac.be
[2] International Centre for Numerical Methods in Engineering (CIMNE)
Universidad Politécnica de Cataluña
Campus Norte UPC, 08034 Barcelona, Spain
e-mail: {narges; michele; agelet; miguel.cervera}@cimne.upc.edu

Key words: *Friction Stir Welding (FSW), Finite Element Method, Remeshing, Arbitrary Lagrangian Eulerian (ALE) formalism*

Friction Stir Welding (FSW) process is a relatively recent welding process. It was invented at The Welding Institute (UK) in 1991. FSW is a solid-state joining process during which materials are not melted. So, the heat-affected zone (HAZ) is smaller and the quality of the welding is better with respect to more classical welding processes. In spite of the important number of applications of the FSW, the phenomena happening during the welding are still not well understood. Therefore, the investigations on this process and especially regarding numerical simulations are still very active, see e.g. [1]. As the material in the neighbourhood of the tool is submitted to extremely high strains, resulting from the mechanical intermixing of the two materials by the tool, advanced numerical simulation techniques have to be extended and developed in order to track the correct material deformation. One of these possible extended techniques is the Arbitrary Lagrangian Eulerian (ALE) formulation. This formulation is used to control the mesh displacement regardless of the real material displacement. It is also used to keep a correct mesh quality during the computation [2, 3]. Sometimes, it is also necessary to remesh at least a fraction of the simulation domain. During these remeshing phases, data are transferred thanks to an original method based on a linear reconstruction of the field on an auxiliary finite volume mesh [4].

The paper presents some comparison of two 3D models of FSW process: one based on a Fluid approach solving for the velocity field [5, 6, 7], and the other based on a Solid approach solving for the position field [2, 4, 8]. It is shown that these two formulations

essentially deliver the same results as far as the temperature and mechanical fields prediction during welding are concerned.

REFERENCES

[1] M. Assidi, L. Fourment, S. Guerdoux, and T. Nelson. Friction model for friction stir welding process simulation: Calibrations from welding experiments. *International Journal of Machine Tools and Manufacture*, 50(2):143–155, 2010.

[2] Official website of metafor : http://metafor.ltas.ulg.ac.be/dokuwiki.

[3] J. Donea, A. Huerta, J.-P. Ponthot, and A. Rodríguez-Ferran. *Encyclopedia of Computational Mechanics*, chapter Arbitrary Lagrangian-Eulerian Methods. John Wiley & Sons, Ltd, 2004.

[4] P. Bussetta and J.-P. Ponthot. A finite volume based data transfer method for remeshing. application to metal forming problems. In *Proceedings of the 18th International Symposium on Plasticity and Its Current Applications*, San Juan, Puerto Rico, January 2012.

[5] M. Chiumenti, M. Cervera, C. Agelet de Saracibar, and N. Dialami. Numerical modeling of friction stir welding processes. *Computer Methods in Applied Mechanics and Engineering*, 254:353–369, 2013.

[6] N. Dialami, M. Chiumenti, M. Cervera, and C. Agelet de Saracibar. An apropos kinematic framework for the numerical modelling of friction stir welding. *Computers and Structures*, 117:48–57, 2013.

[7] C. Agelet de Saracibar, M. Chiumenti, D. Santiago, N. Dialami, and G. Lombera. On the numerical modeling of fsw processes. In *Proceedings of the International Symposium on Plasticity and its Current Applications, Plasticity 2010*, St. Kitts, St. Kitts and Nevis, January 3 - 8 2010.

[8] P. Bussetta, N. Dialami, R. Boman, M. Chiumenti, C. Agelet de Saracibar, M. Cervera, and J-P. Ponthot. Comparison of a fluid and a solid approach for the numerical simulation of Friction Stir Welding with a non-cylindrical pin. *Steel Research International*, 2013.