The pin shape effect on the Friction Stir Welding process

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ABSTRACT

This work shows the development of a numerical technique able to simulate the FSW process in all its complexity together with an ad-hoc material tracing technology. It is a step forward in the field of FSW simulation where a fully thermo-mechanical Finite Element model has been developed. Using the Arbitrary-Lagrangian-Eulerian kinematic framework, the overall computational domain is divided into sub-domains associating an apropos kinematic framework for each one of them. A combination of ALE, Lagrangian and Eulerian formulation for different domain parts is proposed. A sliding mesh, rotating together with the pin is used to handle large deformations and material flow around the pin without necessity of remeshing. The strategy adopted to deal with a generic pin shape (not only cylindrical) together with an accurate definition of the boundary conditions is presented. Special attention for the Heat Affected Zone (HAZ) is taken based on the real process behavior. The sub-domains are joined with direct linking of the degrees of freedom at the contact interface. Heat generation via viscous dissipation (Norton-Hoff and Sheppard-Wright constitutive model) as well as frictional heating due to contact (Norton model) is taken into account (a detailed description can be found in [1, 2]).

The extent of the stir-zone plays a critical role for the quality of the joint-strength. To achieve a high quality and defect-free weld, it is necessary to produce a deep penetrating stir-zone around the pin. The purpose of the current work is to get a better understanding of the material behavior due to the stirring process taking into account the effect of pin shape on the process behavior. The streamlines and trajectories of the stirred material are computed and visualized.

This is an accurate and robust methodology to study the FSW problem allowing for a clear visualization of the material movement at the stir-zone leading to a better understanding of the welding process itself. The results obtained from the proposed numerical method are validated by the experimental evidences.

REFERENCES

[1] An apropos kinematic framework for the numerical modelling of Friction Stir Welding, Dialami N., Chiumenti M., Cervera M. and Agelet de Saracibar C., *Computers and Structures*, **117**, 48-57 (2013).

[2] Numerical Modeling of Friction Stir Welding Processes, Chiumenti M., Cervera M., Agelet de Saracibar C. and Dialami N., *Computer Methods in Applied Mechanics and Engineering*, **254,** 353-369 (2013).