Numerical methods for linear friction welding simulation of aeronautical alloys

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ABSTRACT

Linear Friction Welding (LFW) is an assembly process for producing high quality joins of metallic alloys for aero engines [1]. It consists in enforcing a relative linear motion of the two components to be welded together while applying a compressive force between them. Resulting friction heats the material interface up to viscous state and produces the weld. Its occurrence and quality depend on material, friction and process parameters such as force intensity and oscillation frequency and amplitude. Assembly of new and dissimilar materials requires an improved understanding of the process coming both from experiments and numerical simulation.

Previous numerical investigations of LFW [2-4] have been based on model simplifications, such as artificial process symmetry, to get around intrinsic simulation difficulties. A more comprehensive approach is necessary to both provide more insights on the process, to quantify the error introduced by those simplifications and to consider dissimilar materials.

The process being governed by local heating phenomena, it induces contact-related instabilities, which numerical modelling requires a special attention. High temperature drives material softening and flowing at the close vicinity of friction surface, which is very sensitive to both finite element size and contact algorithm. Automatic mesh adaptation, based on error estimation, is consequently required to ensure the necessary precision in the continuously evolving zone of interest [5], which cannot be achieved by uniform or handily crafted meshes. With utilized Forge® software, the current contact algorithm between deformable bodies leads to uncontrolled and unphysical instabilities. Specific techniques such as contact surface smoothing [6] and bilateral contact formulation are used to handle this issue.

Numerical results are compared to LFW machine monitoring in terms of global mechanical forces and displacements under prescribed pressure. In-process thermocouple measures also provide accurate information close to the welding zone allowing for friction coefficient calibration.

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