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PROCEEDINGS

A Coupled Thermo-Mechanical Finite Element Method with Optimized Explicit Time Integration for Welding Distortion and Stress Analysis

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ABSTRACT

The sequentially coupled thermo-mechanical finite element analysis (FEA) with implicit iteration scheme is widely adopted for welding process simulation because the one-way coupling scheme is believed to be more efficient. However, such computational framework faces the bottleneck of scalability in large-scale analysis due to the exponential growth of computational burden with respect to the number of unknowns in a FEA model. In the present study, a fully coupled approach with explicit integration was developed to simulate fusion welding induced temperature, distortion, and residual stresses. A mass scaling and heat capacity inverse scaling technique was proposed to accelerate the thermal and mechanical analysis, by keeping the actual value of thermal diffusivity in the physical time domain. The heat transfer coefficient was scaled in the cooling stage to reduce the cooling time, the mass scaling factor was optimized by sensitivity study based on different heat input, weld bead size and plate thickness. The fillet welding of a T-joint was employed to verify the accuracy of the fully coupled approach. Owing to the nature of explicit scheme, the proposed approach will be more powerful in solving large-scale welding and additive manufacturing problems.

KEYWORDS

Welding distortion; residual stress; numerical simulation; explicit integration; mass scaling

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