Extrapolation of Welding Simulations via Dynamic Modes for the Estimation of POD Modes

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ABSTRACT

In welding, highly localized transient heat cause nonuniform thermal expansion and contraction, and thus result in plastic deformation in the weld and surrounding areas. Then, residual stress and distortion are permanently produced in the welded structures. Stresses are known to promote fracture and fatigue, and no experimental device gives access to the in-situ three dimensional distribution of stresses. Hence, prediction of residual stresses and distortion, are extremely important during the optimization of the welding process. Due to the complexity of the physical processes involved in welding, Finite Element Analysis play an indispensable role in the numerical simulation of welding. When considering mobile heat sources, numerical simulation have a computational complexity that is nonlinearly growing with respect to the length of the passes involved in the process. In many occasions, the Finite Elements simulations are not feasible in reasonable times.

Recently, projection based model order reduction have been proposed to speed-up welding simulations [1]. A reduced basis of empirical modes is extracted from offline simulations before setting the reduced equations for online predictions. A common way to perform such an extraction of the reduced basis is the POD method. We propose a prediction step in order to extrapolate finite element predictions from a pass to an other, in order to obtain a reduced order model for passes that have not been simulated yet. Two methods to calculate extrapolated simulations are presented and then they will be combined to improve their performance.

A first extrapolation method uses a dynamic mode decomposition (DMD) [2] of the plastic strain. Here the DMD describes the underlying physical mechanisms captured in the data sequence. We assume that these underlying physical mechanisms can be extended from a set of first passes to the remainder of passes. The second extrapolation method is the Physical Fields Shift Method. In this approach, physical transformations in the neighborhood of the heat source are assumed to be almost steady state transformation in a moving frame. The extrapolated plastic strain is introduced in a linear model that predicts the displacement and stress which are used to create a reduced order model.

REFERENCES

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