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A coupled finite element-free Galerkin method for simulating viscous pressure bulging

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ABSTRACT

Viscous pressure forming (VPF) as a kind of sheet flexible-die-forming process developed in recent decades has been playing a much more important role in advanced manufacturing industry because of its distinguishing feature different from other conventional methods. Instead of liquid oil or solid rubber, a semisolid material called viscous medium is served as VPF pressure-transmitting section with the capacity to generate great flowability in the course of the deformation of sheet metal. Inspite of this phenomenon exhibited between sheet metal and viscous medium making VPF itself conspicuous, it also comes up with an inconvenient issue about how to tackle the coupled deformation showing strong nonlinear characteristics, which is difficult for experimental measurement. In this paper, a numerical analysis method aiming at dealing with abovementioned challenging problem is put forward by means of getting finite element method (FEM) and element-free Galerkin method (EFGM) mingled. In order to establish the formulations describing the coupled deformation, a static explicit algorithm based on the Updated Lagrangian (UL) approach is adopted. Sheet metal is modeled through degenerated shell element for expediency, while viscous medium is discretized into element-free Galerkin node for the purpose of eliminating mesh distortion caused by its massive deformation. The very key to accomplish expected numerical analysis is the interaction of interface between sheet metal and viscous medium, which is treated by the penalty function method. A typical numerical example has been simulated by a coupled FEM–EFGM program to demonstrate the effectiveness of the proposed method.

KEYWORDS: viscous pressure bulging, coupled deformation, finite element method, element-free Galerkin method