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Numerical and experimental investigation of viscous pressure forming (VPF) process for metal bellows

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ABSTRACT

Metal bellows are a type of hollow tubular parts with wavy longitudinal sections, which are usually used to absorb mechanical expansion or compression. The incorrectly adjusted process parameters (i.e., axial feeding, feeding velocity, internal pressure, and so forth) in conventional bellows forming processes always lead to forming drawbacks such as fractures or insufficient filling. In this paper, viscous pressure forming (VPF) process is utilized to form metal bellows, which aims at achieving a stable deformation of tubular blank and eliminating forming defects in this process. Finite element analysis (FEA) is used to get a clear inspection of the two forming procedures, namely pre-bulging stage and folding stage. It is observed from the numerical results that the semi-solid viscous medium (pressure-carrying medium) adheres to tube blank in real time. Tangential adhesive stress is generated at viscous medium/blank interface, which will promote the metal flow. Therefore, tubular blank is drawn into the die cavity under the combined action of axial compressive load and tangential adhesive force. As a result, the pre-bulge height can be reduced dramatically, namely tube material is less stretched in the pre-bulging stage. Forming experiments of metal bellows with 10 convolutions are conducted as well. The maximum wall thickness reduction of experimental part is 6.6%, which shows good agreement with that in FEA. VPF process is testified as an effective way to produce metal bellows with good accuracy and small thickness thinning.

KEYWORDS: metal bellows, viscous medium, nickel-based super alloy, metal flow, finite element analysis