Numerical study on tool design for free forming of large and thick plate with unstable blank support

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Abstract

Due to asymmetric configuration of a target product such as turbine blades including rotor and stator, various failures such as scratch, buckling and under-cut derived from sliding and leaning of the intermediate blank are occurred, so it is difficult to control the position of large and thick plate in die cavity. Especially, the hollow-partitioned turbine stator has also asymmetric curved surface, so it is hard to adopt a series of draw-bead or blank holder. Thus, the thick plate in free forming process experiences unstable and non-uniform contact on the tool surfaces in the die cavity.

To easy this unstable positioning restraint in the thick plate free forming, it is necessary to proper design the shoulder angles of the forming punch and the lower die. The rough dimensions of the curved turbine stator in this study are a length of 920.0mm, width of 360.0mm, and height of 170.0mm, and the thick plate material is stainless steel 409L with initial blank thickness of 5.0mm. The shoulder angles are selected to be 30˚, 45˚, 60˚, 90˚ for the forming punch, and 30˚ and 45˚ for the lower die, respectively. A series of combinations of the tool shoulder angles are numerically examined and simulated to survay the suitable angle set. ABAQUS Explicit/Implicit codes are used in the numerical investigation, furthermore, elastic recovery behavior is also considered. As a result, both shoulder angle combinations of (90˚, 30˚) and (90˚, 45˚) for the punch and the lower die are shown that the plate position in the die cavity can appropriately be controlled, and the deformation behavior suitably realized with respect to the stress and strain distribution.

Keywords: Tool Design, Free Forming, Thick Plate, Unstable Blank Support, Finite Element Simulation.

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