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FINITE ELEMENT ANALYSIS OF SUPERPLASTIC BLOW-FORMING OF Ti-6Al-4V SHEET INTO CLOSED ELLIP-CYLINDRICAL DIE

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Abstract

Utilizing commercial DEFORM^{TM} 3D finite element (FE) software, this study performs a series of numerical simulations to investigate the superplastic blow-forming of Ti-6Al-4V titanium alloy into a closed ellip-cylindrical die. In performing the simulations, it is assumed that the die is a rigid body and the titanium alloy sheet is a rigid-plastic material with homogeneous and isotropic properties. The simulations focus specifically on the respective effects of the shear friction factor, the die entry radius, the die height and the die's short-axis length on the thickness, effective stress, effective strain and critical damage distributions within the blow-formed product. Overall, the simulation results confirm the suitability of the DEFORM^{TM} 3D software for modelling the superplastic blow-forming of Ti-6Al-4V titanium alloy.

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Key Words: Finite Element Analysis, Superplastic Blow-Forming, Titanium Alloy, Ellip-Cylindrical Die

1. INTRODUCTION

The term 'superplasticity' describes the capability of certain polycrystalline materials such as 8090 Al-Li alloy, Ti-6Al-4V alloy, and so forth, to undergo extensive tensile plastic deformation prior to failure under specific temperature and strain-rate conditions. The characteristics of superplasticity, namely a low flow stress and a large elongation, have led to the development of a variety of 'superplastic forming' (SPF) processes such as forging, extrusion, blow-forming, and so on (Miller and White [1]; Al-Naib and Duncan [2]). Hwang et al. [3-4] utilized commercial DEFORM^{TM} FE software to investigate the pressurization profile and sheet thickness distribution of 8090 Al-Li sheets blow-formed into closed ellip-cylindrical and rectangular dies. A pressure control algorithm is proposed to keep the maximum stain rate in the deformation zone of the sheet equal to the target value. Senthil Kumar et al. [5] investigated the superplastic deformation behaviour of AA7475 aluminium alloy during its blow-forming into a circular die and compared the results obtained using a simple theoretical model with those generated by ABAQUS FE code. Utilizing MARC simulation software, Morsy and Manabe [6] confirmed the validity of the material characteristics and stress–strain rate relationship obtained from multi-dome tests, and showed that the multi-dome test was applicable not only to simple processes such as free bulge-forming, but also to more complex processes such as rectangular box forming. Hwang et al. [7] developed a mathematical model based upon the finite-difference method to investigate the plastic deformation behaviour of alloy sheets during blow-forming into a closed conical die. It was shown that the theoretical predictions for the respective effects of

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