INVESTIGATIONS ON FORMABILITY OF AA5182 ALUMINIUM ALLOY IN HYDROFORMING OF SQUARE CUPS

by

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Dedicated to

Lord Swaminarayan,

HDH Pramukh Swami Maharaj

and

Mother India

CERTIFICATE

This is to certify that the thesis entitled **"Investigations on Formability of AA5182 Aluminium Alloy in Hydroforming of Square Cups"** being submitted by **Mr. Bharatkumar Amrutlal Modi** to the **Indian Institute of Technology, Delhi (India)** for the award of the degree of Doctor of Philosophy in Department of Mechanical Engineering is a bonafide research work carried out by him under my supervision and guidance. To the best of my knowledge the thesis has reached the requisite standard. The research reports and the results presented in this thesis have not been submitted in parts or in full to any other University or Institute for the award of any degree or diploma.

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ABSTRACT

Importance of lightweight materials like aluminium and magnesium alloys in automobile applications has continuously increased in the recent years due to their high strength to weight ratio and excellent corrosion resistance. Currently, the use of aluminum alloys for sheet metal parts in automobiles is limited due to higher cost and lower formability. Sheet hydroforming, that uses fluid pressure for deformation of a blank, has high potential to manufacture complex auto body components, especially in the case of lower formability materials like aluminium alloys from materials with lower formability due to more uniform strain distribution. Successful production of parts using hydroforming mainly depends on design aspects of tooling as well as control of important process parameters such as closing force or blank holding force and fluid pressure.

In the present work, an experimental set up has been designed and developed for hydroforming of square cups from thin sheet materials. Square cups from 1 mm thick AA5182 aluminium alloy sheets have been deep drawn using the developed experimental set up. The optimum blank shape has been found through Finite Element Analysis. A methodology has been established to determine the variable closing force path for successful hydroforming of the cups with the assistance of programmable logic controller and data acquisition system. It has been found that it is possible to achieve better formability in terms of minimum corner radius and thinning in the case of variable closing force technique than in the case of constant closing force technique.

Influence of process parameters (peak pressure, pressure path and blank holding force) on formability has been investigated through experimental work and numerical

simulations. The experiments have been designed using Taguchi method. Minimum thickness in the formed cups (usually at of the four bottom corners) and minimum corner radius that can be achieved have been considered as the criteria for evaluation of formability. It has been found that the peak pressure is the most important process parameter affecting thinning and corner radius that can be achieved. The variation of the pressure path has the least effect on formability. Regression models have been developed for prediction of minimum thickness in the cup and corner radius as a function of peak pressure and blank holding force.

Apart from the above process parameters, friction plays an important role in sheet metal forming. Influence of friction at blank-die interface on formability of AA5182 alloy in hydroforming has been studied by using two different lubricants (Tellus-46 oil and Teflon sheet). Higher minimum thickness at the corner (0.91 mm) and lower corner radius (20.4 mm) have been achieved. The material can withstand high peak pressure in lubricated conditions with Teflon.

Stress based forming limit criterion proposed by Stoughton has been used for predicting failure in square cup deep drawing of AA 5182 alloy in hydroforming. Analytical procedure has been developed to predict forming limits by modifying Stoughton's stress based criterion using Barlat's 3-parameter yield function. Results showed that prediction based on stress based criterion agreed more closely with the experiments than the strain based forming limit diagram because of observed change in strain path at the corners.

Key Words: Sheet Hydroforming, Aluminium Alloys, Peak Pressure, Pressure Path, Blank Holding Force, Finite Element Analysis, Forming Limit Diagrams.

Table of Contents