Finite element analysis of Single Point Incremental Sheet Forming Process for Different Cup Shapes from AA1070 alloy Sheet and Validation through CNC Machine

A. Raviteja
P. G. Student, M. Tech (AMS), Roll No. 1011P0309, Department of Mechanical Engineering, JNTUH College of Engineering, Hyderabad.

Under the Guidance of Dr. A. Chennakesava Reddy, Professor, JNT University Hyderabad

ABSTRACT

Single point incremental forming (SPIF) process is a new process for manufacturing sheet metal parts which is well suited for small batch production or prototyping. In this process a simple ball shaped tool is moved along a predefined path to impose plastic deformation locally in the sheet. The process is very flexible and can be carried out on a computer numerical control (CNC) milling machine. The path of the tool is controlled by a part program generated using computer aided manufacturing (CAM) software. In a series of research on deep drawing process, abundant explorations have been made to fabricate various cups using different materials such as AA1050 alloy, AA1070 alloy, AA1080 alloy, AA1100 alloy, AA2014 alloy, AA2017 alloy, AA2024 alloy, AA2219 alloy, AA2618 alloy, AA3003 alloy, AA5052 alloy, AA5039 alloy, Ti-Al-4V alloy, EDD steel and gas cylinder steel. From the literature it is found that the incremental sheet forming is restricted by different parameters: the wall angle, tool diameter, incremental size and the initial sheet thickness. Recently, finite element analysis (FEA) has been a powerful tool to evaluate the final part characteristics.

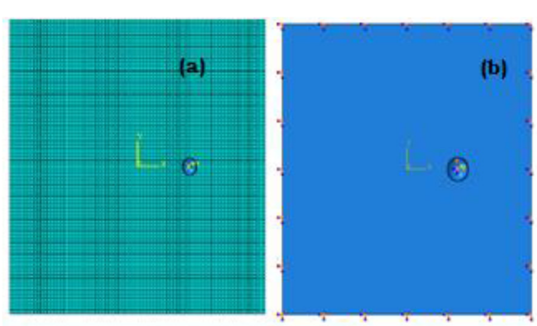

Figure 1: Finite element modeling: (a) mesh generation and (b) boundary conditions.

Present work was focussed on the finite element analysis of SPIF process of AA1070 alloy using commercial software ABAQUS. The investigation was to optimize the process parameters such as blank thickness, step depth, coefficient of friction and tool radius to fabricate cylindrical and conical cups. The design of experiments was carried out using Taguchi technique.

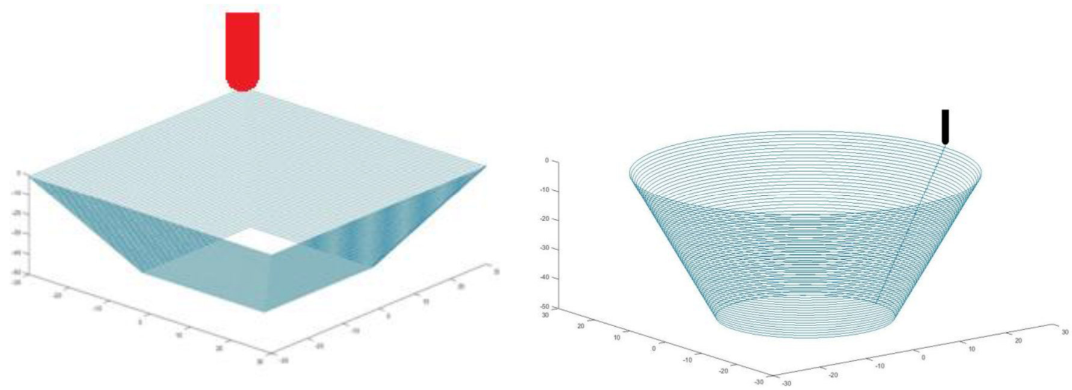

Figure 2: Tool path generation.

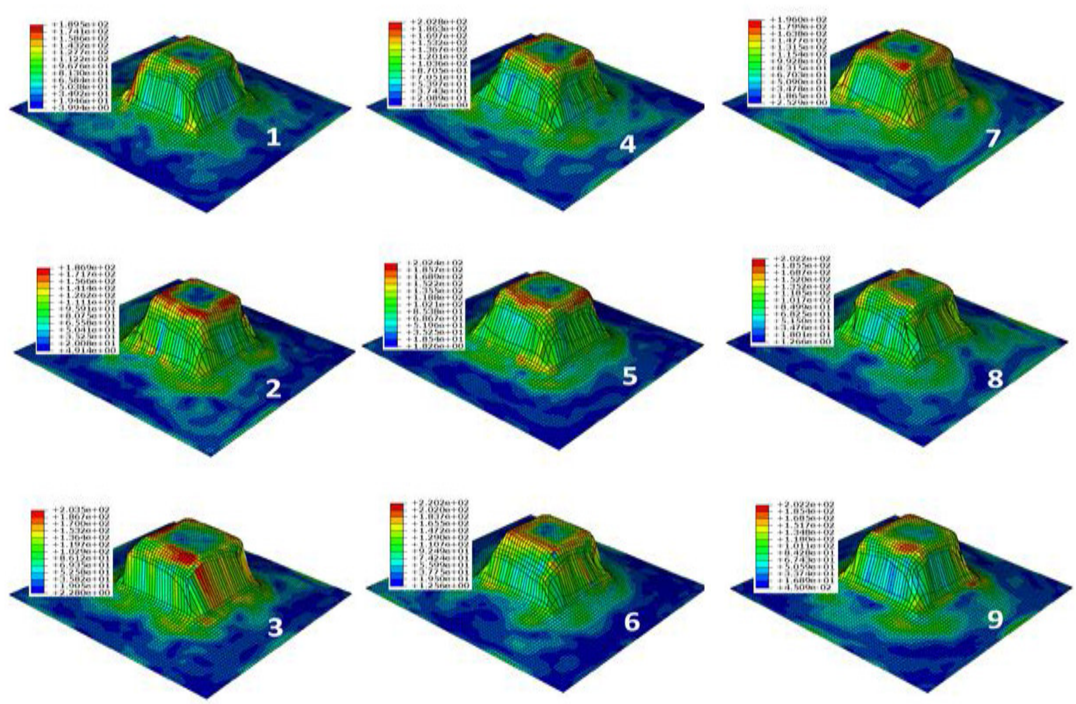

Figure 3: Raster images of von Mises stress in the pyramidal cups.

In the present work, the finite element analysis and Taguchi techniques are successfully implemented to simulate single point incremental deep drawing process for the AA 1070 sheet. The major parameters, which influences the formability of cylindrical cups, are the sheet thickness and step depth. The major parameters, which influence the formability of conical cups, are the tool radius and coefficient of friction.

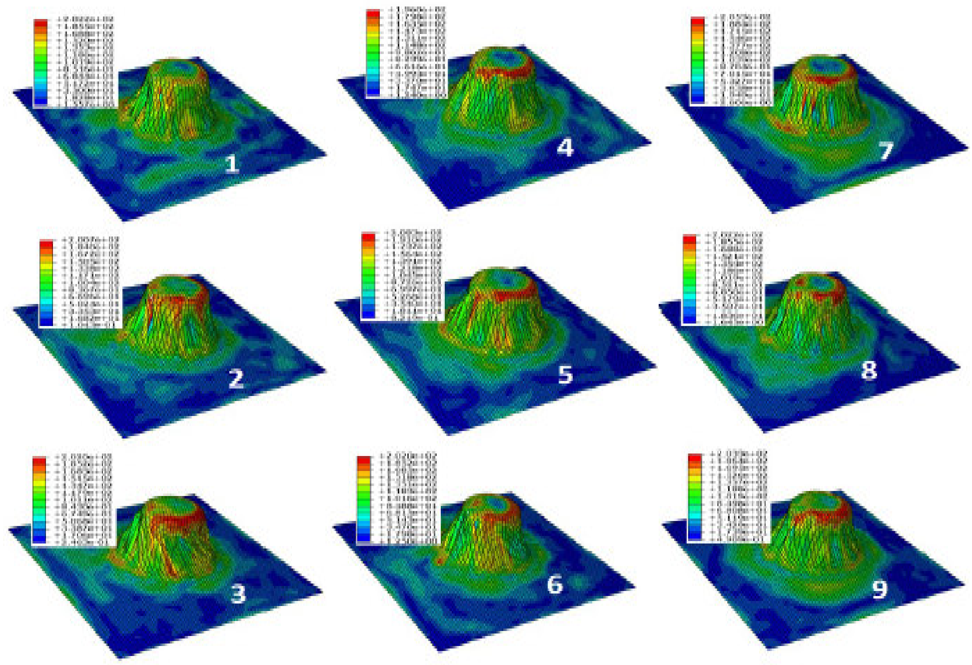

Figure 4: Raster images of von Mises stress in the conical cups.

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