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DEEP DRAWING PROCESS FOR ALUMINIUM ALLOY CYLINDRICAL CUPS

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ABSTRACT

In this research, the deep drawing dies are designed by using finite element software to save time and facilitate the design process and FE Method is used to simulate the drawing process to select the best die design, also. A commercially available finite elements software (ANSYS 14.0 APDL) was used to perform the numerical simulation. With this regard, the effects of various parameters such as punch pressure, blank diameter, frictional and connection conditions and material flow were investigated. AA8011 used as blank material. Experiments done on 100 tonne deep drawing setup. 1.5 mm thickness sheet give best results. Finite elements results were compared with experimental results.

INTRODUCTION

Sheet metal forming processes are technologically among the most important metalworking processes. Products made by these processes include a large variety of shapes and sizes. Typical examples are automobile bodies, aircraft panels, appliance bodies, kitchen utensils and beverage cans. [1] R.Uday Kumar et al. has performed numerical simulation for aluminium alloys cups. In this study conical shape die used for obtaining fukui's conical cup, This test is belongs to cup drawing test. Also in this study the diametrical ratio has been determined for materials and diametrical ratio is expressed as formability. These test results were show sensitive to thickness of sheet metal and punch diameter. The process carried out without help of blank holder. [2] Kopanathi Gowtham et al. has obtained cylindrical cups for aluminium alloys by using multi stage deep drawing. The increased the die fillet radius decreases of punch force for draw material and an uneven thickness distribution. In this work, experimental results and to validate the simulation done, several simulations were performed by varying the die radius. [3] K Mohan Krishna et al. has analysed deep drawing process with varying punch and die geometry. The obtained Finite Element result allows finding optimum draw ratios in deep drawing. In this work, requirement of different stages for successfully drawing has find. [4] Based on the previous paragraphs, it is concluded that, in all previous work, cylindrical cups are produced either by non-conventional processes and or in multi stages. Therefore the demand for a simple and economically efficient process is significant. In the present work, a novel, simple process for deep drawing of cylindrical cups without blank-holder has been proposed. F.E. analysis has been used to optimize the experimental setup design through the exploration of the effects of die and punch geometry on the limiting drawing ratio (LDR) and on the drawing load associated with the new process. Moreover, FE analysis has been employed to optimize parameters of the proposed process such as half-cone angle, fillet radius and aperture (throat) length, of the die together with punch fillet radius. Simulation results were confirmed via experimental work.

METHODOLOGY

In this paper the numerical simulation of conical die for production of cylindrical cup has been performed. The numerical simulation is obtained through finite element analysis. F.E. Analysis done by ANSYS 14.0 software. The material is used in this analysis is aluminium alloy (AA8011). The same FEA setup is used for experimental work. In this process the circular blank with dimension is clamped on conical die surface and drawn into conical cup by using flat bottom cylindrical punch. The punch moves continuously into sheet metal until the cup gets shape without using the blank holder. In last step, simulation results were confirmed via experimental work.

FINITE ELEMENT ANALYSIS AND MATERIAL PROPERTIES

In the present paper, ANSYS 14.0 APDL finite element analysis software has been used for modelling and simulation of the deep drawing process. The punch and die were modeled as rigid bodies. Coefficient of friction

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in the blank–punch interface was assumed to be 0.01. A displacement load is applied to the faces of punch in negative direction. The punch speed controls by iterations solution. All degrees of freedom fixed in case of die. The blank is constrained by symmetry boundary conditions and the contact with the tool set. Because of symmetry, only a quarter model is sufficient for FE analysis. Material model is established using mechanical properties obtained from tensile tests. For the AA8011 the modulus of elasticity, E is 65 GPa and Poisson's ratio is 0.3 as found from the tensile test.

EXPERIMENTAL PROCESS

Experiments were conducted on a 100 tonne universal testing machine, with a data acquisition device. Punch load versus punch stroke is plotted and displayed on screen and saved on an Excel work sheet for later manipulation. The die set consists of a conical die with 18° half-cone angle with a die groove to prevent die rotation. In the present study aluminium alloy (AA8011) sheets with thicknesses 1.5, 1.6 and 1.7 mm has been used for deep drawing of cylindrical cups with 45 mm diameter. Figure 1 is showing setup of deep drawing process.

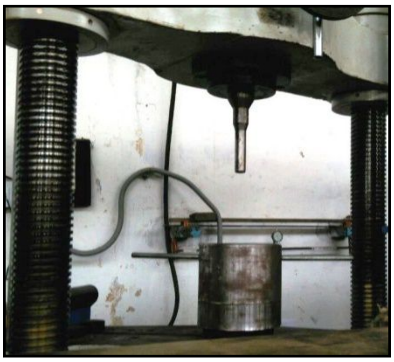

Fig 1: Deep Drawing Setup

GEOMETRICAL PARAMETERS

Geometrical parameters for experiment are listed in Table 1.

Table 1: Geometrical Paramrters

Parameters	**Value**
Half Cone Angle	18°
Punch Length	50 mm
Fillet Radius of punch	5 mm
Fillet Radius of die	10 mm
Conical Section Length in Die	90 mm
Blank Thickness	1.5, 1.6 & 1.7 mm
Blank diameter	45 mm

RESULTS & DISCUSSION

Fig. 2 is showing simulation results and experimental results regarding the variation of punch pressure along the punch displacement. Punch pressure reaches its maximum value when the partially deformed blank enters the throat of the cylindrical die. In simulation the punch pressure is maximum for 1.7 mm thickness of sheet and minimum for 1.5 mm.

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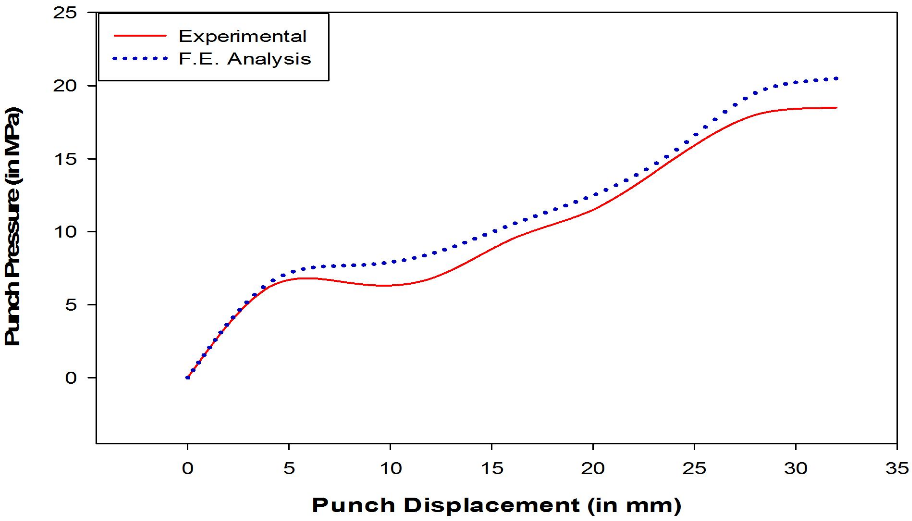

Fig 2: Punch pressure with punch displacement

Figure 3 is showing different stress on cup wall region with the thickness variation from 1.4 to 1.7 mm. In simulation the all stresses are maximum for 1.7 mm thickness of sheet and minimum for 1.5 mm. The simulation results equal to the experimental results.

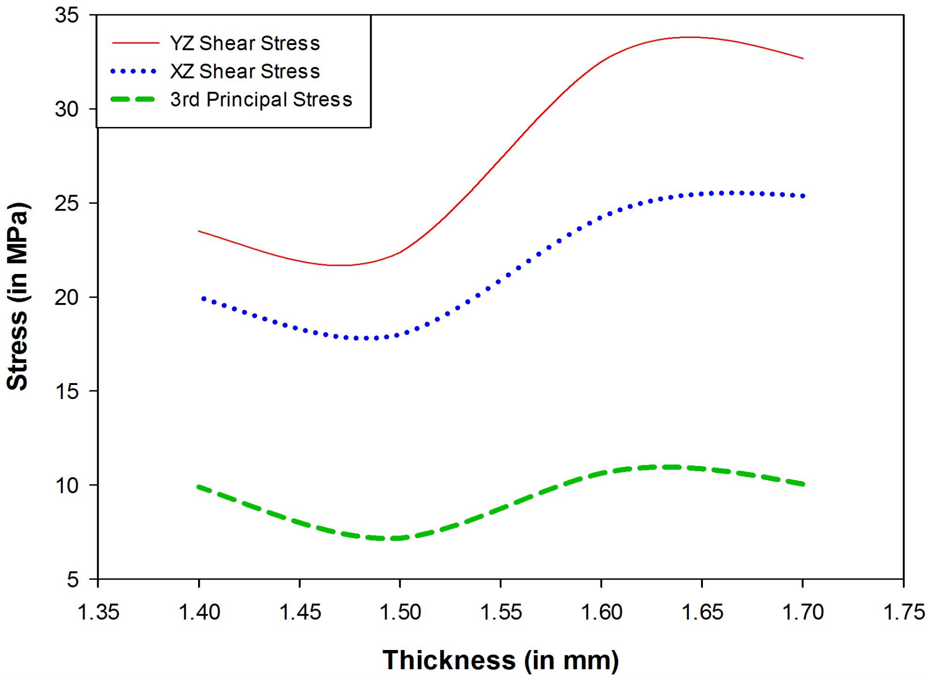

Fig 3: Different Stresses in Cup Wall with thickness variation

Figure 4 (a-d) are showing that the quarter model of successful deep drawing cups. The variations of hoop stress on cup wall from 1.4 to 1.7 mm blank thickness are clearly showing in below. The cup wall is subjected to compressive stress in the circumferential direction. This hoop stress is responsible for wrinkling; therefore it is

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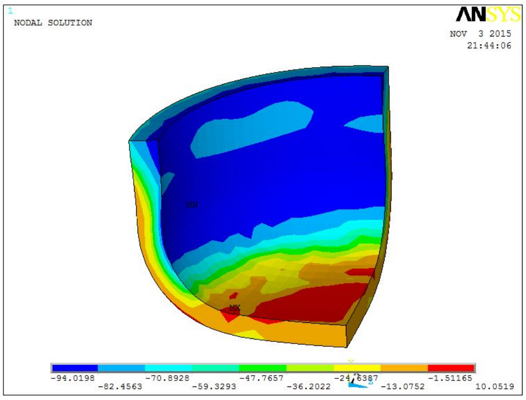
important to reduce. This stress is very much minimum at 1.5 mm thickness. And it was observed that the hoop stresses is higher above and below 1.5 thickness.



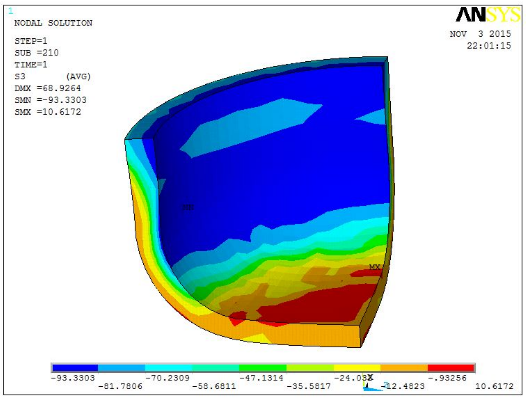
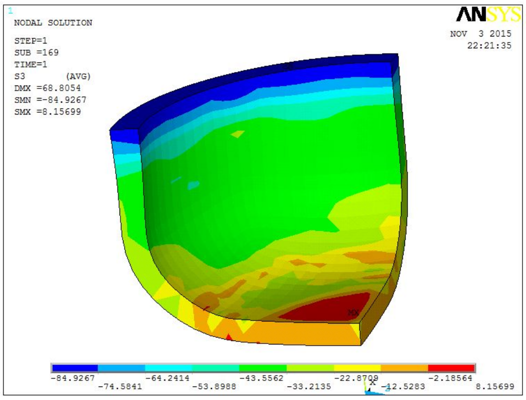


Fig. 4 (a) Stress on thickness = 1.7 mm *(b) Stress on thickness = 1.6 mm*



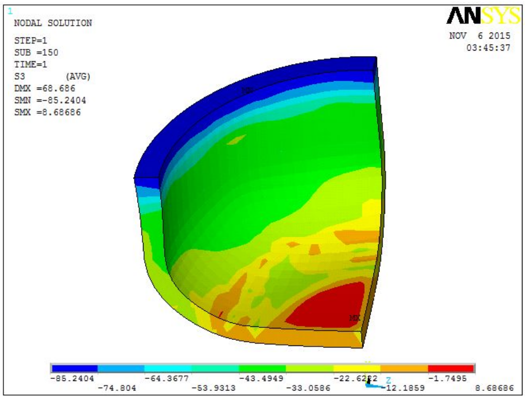


Fig. 4 (c) Stress on thickness = 1.5 mm *(d) Stress on thickness = 1.4 mm*

Figure 5 is showing that, the successful experimental deep drawing cup of AA8011 material. The numerical cup of 1.5 mm thickness is validate from experimental cup.

Fig. 5 Successful Deep Drawing Cup for AA 8011 of 1.5 mm thickness

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CONCLUSIONS

The investigations have shown a good agreement between the numerical and experimental results for the various stresses in the surfaces of a cylindrical workpiece. 1.5 mm sheet has good results compare to other two thicknesses on same geometry. Through the comparison between the experimental and FEM, it has concluded that finite elements method better for experimental method in predicting the best die design, and a good match between the two methods was found.

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