Research Paper Engineering

Impact of Various Die Radious on Cylindrical Cup Strength Using Finite Element Analysis

* Amit Kumar Gupta ** ShailendraKharkate

* Asst.Prof. Mechanical,IET-DAVV,Indore,RH-12,Scheme No.54 Sector-A, Vijay Nagar, Indore(M.P.)-452010

** 162, Annapurna road, Near Inderprashat garden, Sidhhipuram colony, Indore (M.P.)-452009

ABSTRACT

With the help of metal forming simulation we can identify the problem areas and solutions can be validated in computers without any expansive shop floor operations prior to any tool construction. Majority of automobile and appliances components are made by deep drawing sheet metal process. So these growing need demands a new design methodology based on metal forming simulation. Metal forming simulation is also helpful at the product and tool design stage to decide various parameters. Optimization of process parameters in sheet metal forming is an important task to reduce tryout and manufacturing cost. To determine the optimum values of the process parameters, it is essential to find their influence on the deformation behavior of the sheet metal. This paper describes the methodology by which the influence of various parameters on deformation behavior of the sheet metal can be predicted and the data of post processed result can be used during product design and tool design. The virtual FE simulation can predict various defects during deep drawing process at the product design stage. The study performed in this paper to predict the effect of parameters on formability of a trapezoidal cup using Altair Hyper Form radioss predictive tool. The formability analysis is performed for various cases of different values of parameters blank holding force and friction coefficient and various virtual tryout set is developed and thickness variation are analyzed. The die, punch, binder and blank are the main components developed as virtual tryout set.

Keywords : Die radius, FEA, FLD, Deep drawing process.

INTRODUCTION

The majority of automotive and appliances parts are produced by means of the sheet metal forming technology. With the increasing popularity of FE simulations are performed repeatedly in the design feasibility studies of production tooling and die designs. Sheet metal forming is a technique by which most body parts are produced in automobile industries. One of the most important formative processes of sheet metal parts in manufacturing industries is deep drawing (DD). The DD process is a technique/tool which is often applied to fabricate hollow sheet metal parts with high drawing ratios or complicated shapes. In sheet metal forming, a blank sheet is subjected to plastic deformation using forming tools to conform to a designed shape. During this process, the blank sheet is likely to develop defects if the process parameters are not selected properly. Therefore, it is important to optimize the process parameters to avoid defects in the parts and to minimize production cost. Optimization of the process parameters such as die radius, blank holder force, friction coefficient, etc., can be accomplished based on their degree of importance on the sheet metal forming characteristics [1].

Drawing is a manufacturing process very used in the industry due to its versatility and good mechanical properties (as good surface finish and dimensional accuracy) of the parts. Successful drawing operations require careful selection of process parameters and consideration of many factors.[2] The main variables involved in this type of process are:

1. Die radius
2. Friction
3. Punch Radius
4. Blank Thickness.

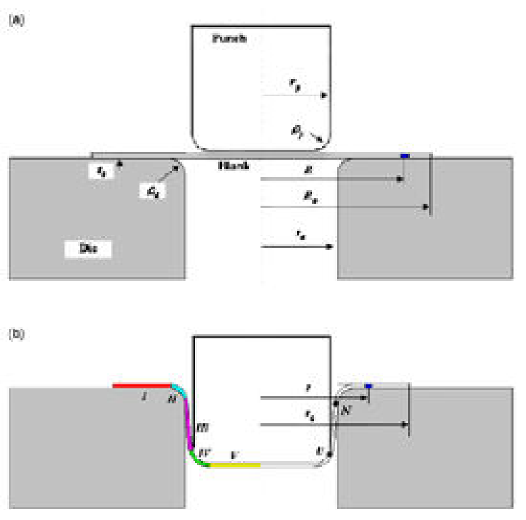

Fig.1 Deep drawing for a circular cup (a) initial stage and (b) intermediate stage.

PROCESS METHODOLOGY (DETAILS WITH FIGURES)

The formability of blank sheet depends on the process parameters such as die radius, pressure, punch speed, friction coefficient, and blank holder force. Fracture and wrinkle are the major modes of failure in sheet metal parts. Hence, using proper process parameters are essential to restrict wrinkling tendency and avoid tearing. One of the quality criterions in sheet metal formed parts is thickness distribution. In this study, a cylindrical cup with CRAS steel and blank thick of 1 mm is simulated by using Altair's Hyper Form radioss to study the effect of these parameters on failure modes and thickness distribution.[3]

Fig.2 Cylindrical Cup

PREPARING THE MODEL:

The component to be formed is taken into Hyper Form as an IGES data and die design was carried out for the component using the available features in Hyper Form.

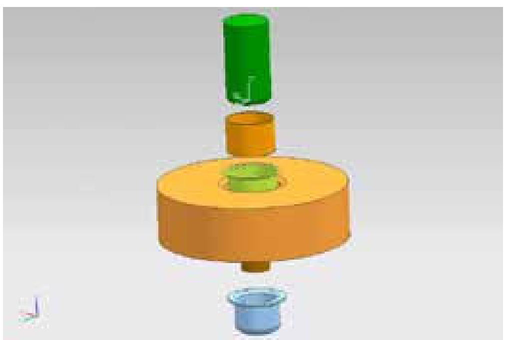

Fig.3 Finite element model used in simulation

COMBINATIONS OF PROCESS VARIABLES

The various combinations of the process variables are i.e. Die radius, friction coefficient, Max. strains

TABLE – 1
EFFECT OF VARIATION IN DIE RADII ON MAX. STRAIN DURING DRAWING OPERATION

S.NO.	RADIUS (mm)	FRICTION COEFFI-CIENT	MAX. STRAIN
1	1	0.125	4.10
2	2	0.125	3.91
3	2.5	0.125	3.89
4	3	0.125	2.72

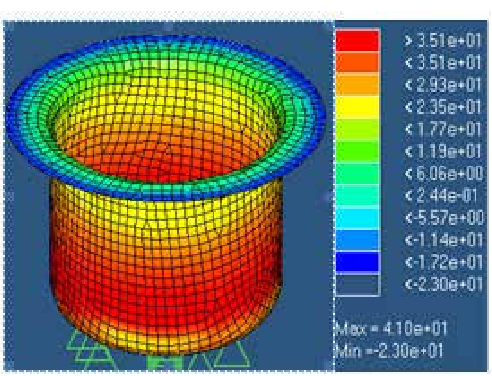

Fig.4 Effective strain Values for 1mm Die radius

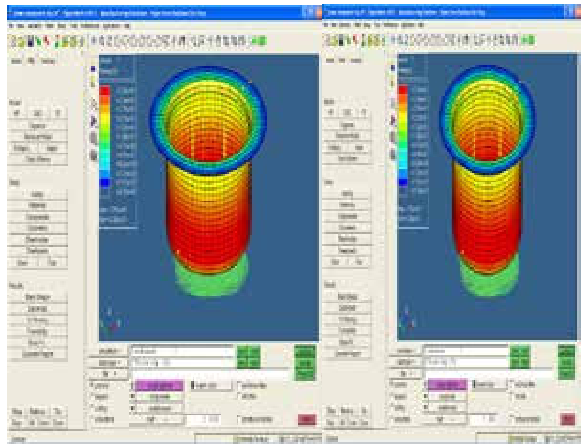

Fig.5 Effective strain Values for 2 mm Die radius

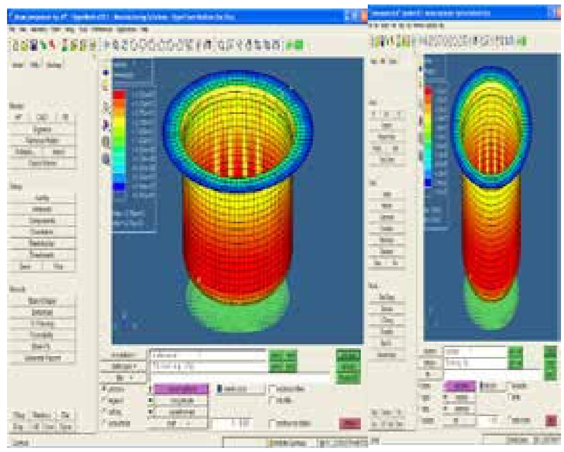

Fig.6 Effective strain Values for 2.5 mm Die radius

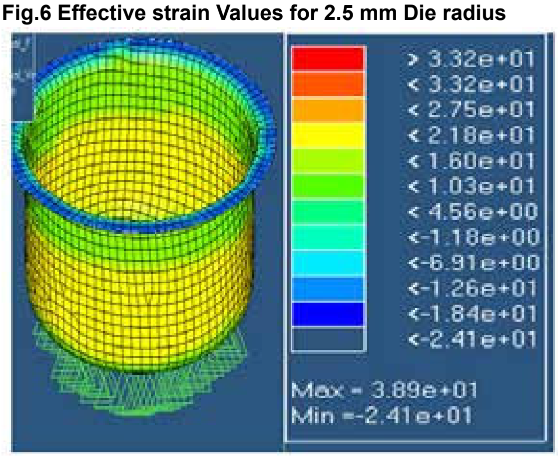

Fig.7 Effective strain Values for 3 mm Die radius

RESULTS AND DISCUSSION

Fig. shows the analysis result to investigate the effect of variation in die radii on load required during drawing operation, when the friction between the die and the blank are considered to be constant as 0.125 respectively and the die radii varies as 1, 2, 2.5, 3mm. Table 1 shows the load required in drawing operation during each pass, for different die radii.[4]
Different simulations with different die radii were performed. According to John Monaghon [1] et al. , as the die radius is reduced, it increases the amount of force to draw the material, the increased force on the punch & greater difficulty getting the material around the die radius causes stretching marks on the cup wall and an uneven thickness distribution.

To verify the above experimental results and to validate the simulation done, several simulations were performed by varying the die radius.

Comparing the Max. Principal strain values of the drawn cups, it was found that, max. Principal strain values are decreasing as the die radius is decreasing. Comparing the effective stress values of the drawn cups, it was found that, effective stress value was increasing as the die radius is decreased as shown in Fig. Comparing the Max. principal stress values of the drawn cups, it was found that, max. Principal stress values are increasing as the die radius is decreasing.[5]

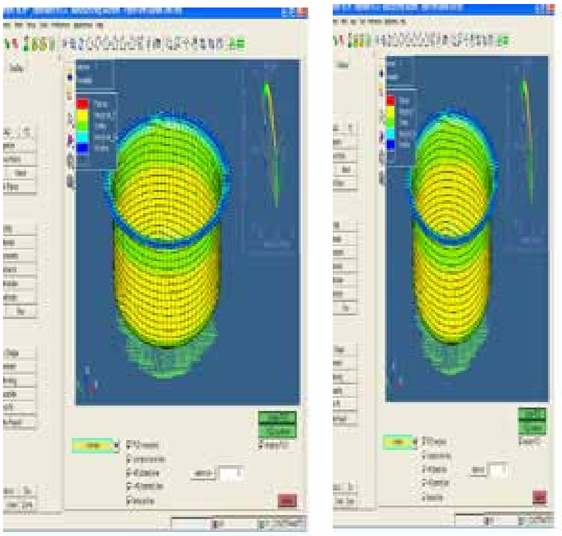

Fig 8 . Forming Limit Diagram of Cylindrical Cup

tFUTURE PLANS

For such component the defects can also be controlled by selecting optimized punch speed. Further the research and study can be extended to predict the effect of punch speed on formability of cup drawing and on thickness distribution. Also with the help of DOE techniques the above parameters can be optimized. For DOE study Altair's Hyper Study tool is very much suitable and applicable.

CONCLUSIONS

Metal forming, product design & Die design industry can be largely benefited to carry the virtual forming simulation and thus reduce the manual tryouts which involves time and money. Simulation technique can be used effectively to optimize the die design and process parameters. Using Hyper Form and available CAE technology any modification required to modify the die or the component can be carried out in the software and multiple iterations can be performed and accordingly the design can be finalized.

REFERENCES

[1] Metal Working, "Sheet Metal Forming", ASM Handbook, Volume 14B, (2006), U.S.A. | [2] Djavanroodi F., A. Derogar, "Experimental and numerical evaluation of forming limit diagram for Ti6Al4V titanium and Al6061-T6 | aluminum alloys sheets", Journal of Materials & Design, pp 4866-4875 (2010). | [3] Sansot P., U. Vitoon, J. Jittichai, S. Surasak, "Determination of Forming Limit Stress Diagram for Formability Prediction of SPCE | 270 Steel Sheet", Journal of Metals, Materials and Minerals, Volume 21, pp 19-21, (2011). | [4] Damoulis G. L., G. Edson, B. G. Ferreira , "Analysis of the Industrial Sheet Metal Forming Process using the Forming Limit | Diagram (FLD) through Computer Simulations as Integrated Tool in Car Body Development", International Journal of Mechanical | Sciences, pp 210-217,(2002). | [5] ASTM Handbook, "Standard test methods and Definitions for Mechanical Testing of Sheet Product", ASTM A370, (2011), U.S.A. |