Formability Analysis of Deep drawing Process by Finite Element Simulation

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Abstract: ***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. 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. 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. The finite element simulation analysis is carried out to predict the effect of parameters on formability using various finite element simulation software available. In the present work formability analysis is carried out for gear cover by varying parameters like blank holding force, friction coefficient and blank size using Altair HyperForm, LS-DYNA predictive tool. Various iterations are performed and from result thickness variation and strain generated from forming limit diagram are analyzed. The die, punch, binder and blank are the main components developed as virtual tryout set. A constant blank holder force strategy was applied and the results were compared for various blank holder force values along with other parameters used.***

Keywords: Finite Element Analysis, Deep drawing, simulation

1. 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. The deep drawing process is a technique/tool which is often applied to fabricate hollow sheet metal parts with 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].

Deep drawing is a process for shaping flat sheets into cup-shaped articles without fracture or excessive localized thinning. The design and control of a deep drawing process depends not only on the workpiece material, but also on the condition at the tool workpiece interface, the mechanics of plastic deformation and the equipment used. The most used numerical method for numerical simulation of the forming process is finite elements method (FEM) [2]. The numerical simulations included the evaluation of the influence of various factors on the production process, the analysis of various test geometry, as well as the evaluation of loads on the production process. The FE analysis software is regularly employed in the design assessment of stamping tooling and dies in automotive industries, and the process simulation approach has been established as a practical methodology in the part formability and stamping failure predictions. Technology preparation phase of deep drawing process includes:

- Prediction of fracture
- Prediction of wrinkling
- Prediction of final sheet thickness
- Determination of optimal initial blank geometry

In the current work case is studied for deep drawing process of gear cover, in which problem of wrinkle and tearing is severe. Fig.1 shows tearing and wrinkles occured during drawing of a gear cover.

Figure 1: Tearing and wrinkling problem faced during drawing gear cover

To analyze the problem finite element simulation of above process is carried out in which effect of parameters like blank holding force, blank size and friction coefficient on the formability of gear cover for 2 mm blank thickness is studied to select proper process parameters during drawing of a gear cover to reduce above problems.

2. Process Methodology

The formability of blank sheet depends on the process parameters such as blank holder force, blank size and lubrication condition along with the material properties of blank used for drawing a given component. Fracture and wrinkle are the major modes of failure in sheet metal parts. Hence, using proper values of process parameters are essential to restrict wrinkling tendency and avoid tearing. One of the quality criterions in sheet metal formed parts is thickness distribution. The methodology followed for finite element simulation analysis of a gear cover to study the effect of various process parameters is given in Fig. 2.

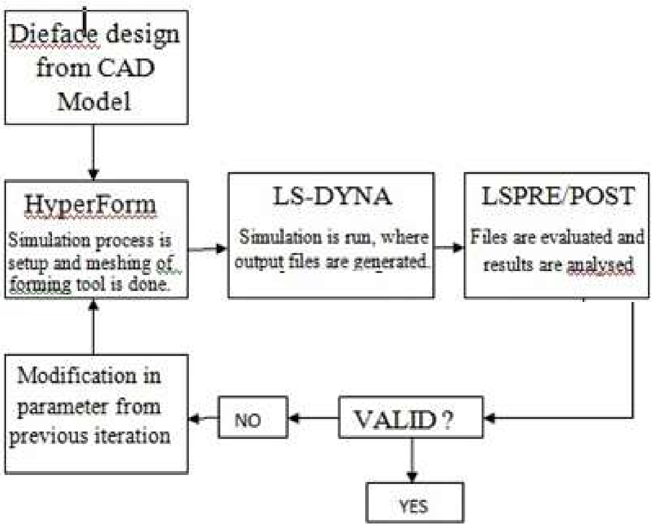

Figure 2: Methodology adopted for finite element simulation of gear cover

The geometry of gear cover is shown in Fig. 3 and mechanical properties of 2 mm thickness EDD sheet used for drawing gear cover is shown in table 1.

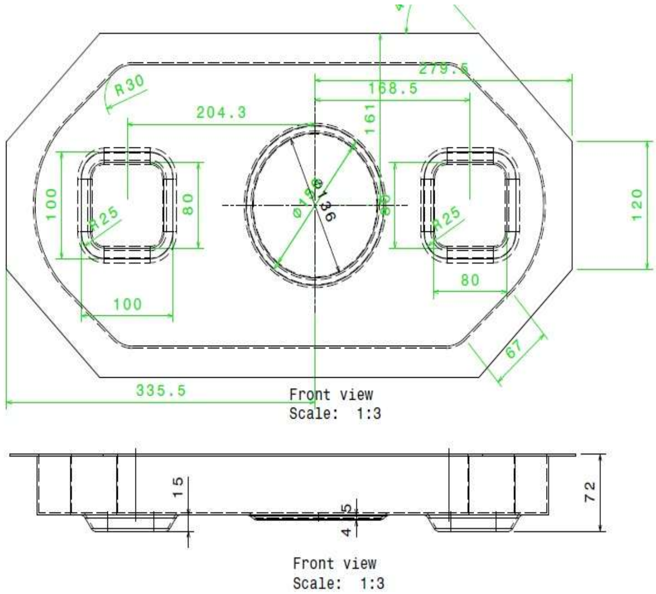

Figure 3: Drawing of a gear cover used in a rotavator assembly

Table 1: Mechanical properties of EDD sheet used for drawing gear cover

Material Properties	Values
Young Modulus(E)	210 KN/mm^2
Poission's Ratio(μ)	0.3
Density(rho)	7.8×10^{-6}
Ultimate tensile strength(UTS)	0.232 kN/mm^2
Strain hardening exponent	0.2575
Plastic Strain ratio(r)	1.5
Yield Strength	0.151 kN/mm^2

Preprocessing

Preprocessing is carried out in HyperForm software in which boundary conditions such as material properties, tool and blank meshing, tool motion etc. is applied to generate a required tooling setup for carried out a simulation analysis. Fig. 4 shows simulation setup generated at the end of preprocessing for a gear cover.

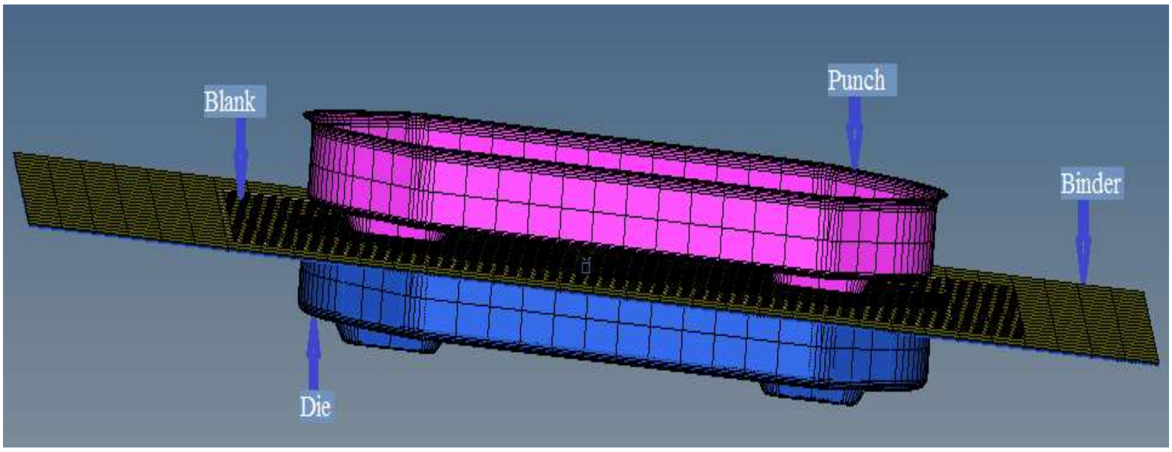

Figure 4: Simulation setup of a gear cover

Post-processing

In postprocessing, simulation is run in LS-DYNA software to analyze the effect of various parameters on the formability of gear cover, depending on result of simulation modification in the parameters for next iteration is carried out until desired output is obtained.

3. Results and Discussion

a) Effect of the Blank holding force

To study the effect of the blank holder force on formability of gear cover, finite element simulation analysis is carried by varying blank holder force values as 350, 250, 150, 175 KN, while other parameters like friction coefficient and blank size is maintained constant as 0.125, 730×450 mm. The result obtained for various blank holding force values is shown in Fig 5. The results obtained from simulation analysis shows that for blank holder force values i.e. 350 and 250 KN, the wrinkling tendency over the flange area is reduce but problem of cracks is sever. Where as it is shown that for 150 KN blank holding force value, cracking tendency over the blank surface is reduce but problem of wrinkling is increased. For 175 KN BHF value cracking tendency reduced however wrinkling is observed over the flange area as shown in the Fig.5.

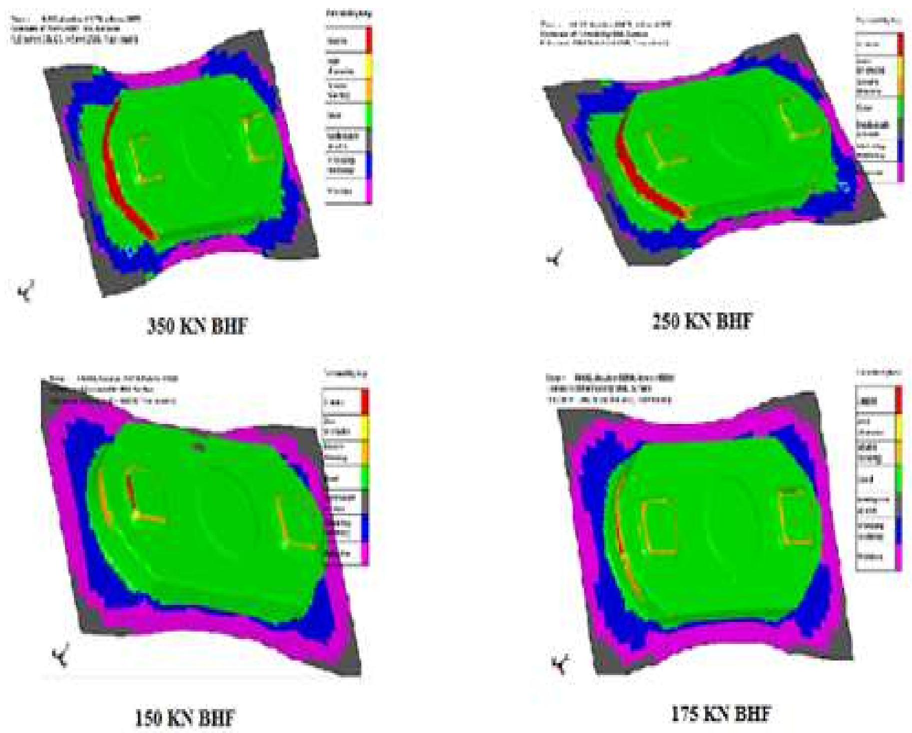

Figure 5: Effect of blank holding force on formability of gear cover

b) Effect of the Friction Coefficient:

To study the effect of friction coefficient over the flow of material during drawing process friction coefficient values 0.125, 0.02, 0.04 and 0.06 is analyzed with 175 KN BHF value. The simulation result obtained for 0.04 coefficient of friction and 175 KN BHF values shows a required stretching as shown in Fig. 6.

c) Effect of blank size:

In order to study the effect of blank size on the formability of gear cover, iteration is carried out for 720x440 mm blank keeping other parameter such as blank holding force and friction coefficient constant as 175 KN and 0.04. Fig.6 shows result of simulation for 175 KN BHF, friction coefficient 0.04 and 720x440 mm blank size.

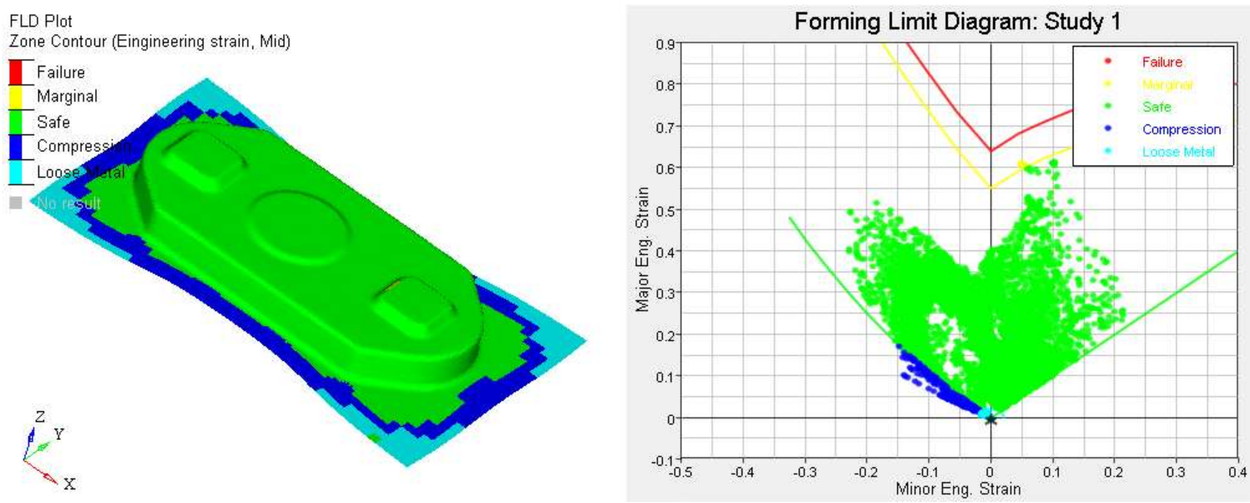

Figure 6: Result of simulation for 175 KN BHF, friction coefficient 0.04 and 720x440 mm blank size

4. Conclusion

From finite element simulation analysis of deep drawing process of gear cover following conclusions are drawn,

1) During deformation of material in deep drawing, it is quite difficult to control defects like wrinkling and tearing, as for higher values of blank holding forces wrinkling tendency over flange area decreases but at the same time problem of tearing is sevear. For lower values of blank holding forces cracking problem removed but wrinkling tendency over the flange area increases.
2) In case of deep drawing process of gear cover for BHF values higher than 175 KN the problem of cracks during deformation is sevear, whereas problem of wrinkling reduced.
3) For BHF values lower than 175 KN the problem of wrinkling over the flange is sever but problem of cracking removed.
4) As flow of material during deformation is affected by the lubrication condition, over lubrication may leads to excessive flow of material which leads to cracks. whereas insufficient lubrication leads to improper flow of material during drawing process leads to problem like cracks and tear.
5) Size of blank used during drawing process plays an important role in uniform stretching of sheet during deformation of material.
6) It is observed that numerical results on deformation behavior are very close to the experimental observation.

References

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