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Some Design Consideration of Single Stage Drawing of Cylindrical Cup Using Altair Hyperworks

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Abstract: **HyperForm is the module of Altair Hyperworks used for formability analysis and prediction various defects like wrinkles, spring-back and thinning occurred in sheet metal drawing process. A sheet metal drawing process is widely used in industry for producing seamless cup formed parts in automobile, aircraft and household applications. During the product design and tool design designer are still adapts trial and error method to decide blank shape, blank size, draw tool and process parameters. Computer aided engineering (CAE) plays very significant role in the decision making of various parameters of sheet metal forming processes and it helps to designer during product design as well tool design stage to decide optimum and accurate process parameters. The use of CAE software such as HyperForm during product design and tool design stage minimizes the tool trial time and cost. This paper describes the study of effect of die parameter such as die radius and process parameters such as blank holding force for different thicknesses on defects like wrinkles and thinning during sheet metal single stage drawing of cylindrical cup. Altair HyperForm CAE tool is used for this investigation as a virtual tool and the results are compared with actual production of component by designing and developing tool for drawing of sheet metal. The study reveals that the die radius influences on defects like wrinkles. The result of Altair HyperForm well matches with the actual produced products.**

Keywords: **Formability, Wrinkles, % Thinning, Deep Drawing.**

1. INTRODUCTION

Metal forming are the main methods of manufacturing in this process the material shape is formed by applying force to the piece. Metal forming is used for achieving complex shape products and, improvingthe strength of the material. In this method, thin sheets of metal are shaped by applying pressure through dies.

Sheet metal forming is very important for metals because nearly 50% of metals are produced in sheet metals. Sheet metal forming is done by many ways such as shearing and blanking, bending stretching, spinning and deep drawing. Those methods are widely used for producing various products in different places of industry. The parts manufactured by sheet metal forming are widely used in automotive and aircraft industries.

Deep drawing is one of the most important sheet metal forming processes. A 2-D part is shaped into a 3-D part by deep drawing. According to the definition in DIN 8584, “deep drawing is the tensile-compressive forming of a sheet blank to a hollow body open on one side or the forming of a pre-drawn hollow shape into another with a smaller cross-section without an intentional change in the sheet thickness.”

In the deep drawing process, flat sheet of metal (called blank) is placed over the die, and with the help of the punch, blank is pressed into the die cavity. Blank holder applies pressure to the blank in the flange region during the deep drawing process (3). In manufacturing processes the main goal is to obtain defect free end product. Recently, there are two main approaches to achieve these goals. One of them is the application of knowledge-based expert systems, which are generally based on simplified plasticity theory and empirical technological rules. There are a great number of papers dealing with the use of knowledge-based systems both in sheet and metal forming. However, the exclusively knowledge based solutions have certain disadvantages; they usually cannot provide an enough accurate solution to the problem since systems are generally based on simple technological rules with limited validity. Therefore knowledge based systems cannot predict for example the material flow, and usually cannot provide the accurate stress and strain distribution inside the component. The first step of manufacturing is the designing process, which enormously affects the whole manufacturing process. The designer must have knowledge about possible problems and their solutions during production. Many researchers have been completed in various manufacturing processes because of the knowledge needed to achieve better quality product. This work represents the initial stages of application and utilization finite element analysis (FEA) for Deep drawing process as in manufacturing domain. Use of FEA at early design stage of tool design for deep drawing helps to predict defects and save time and trial cost after manufacturing tool.

In the previous research work, the researchers considered different process parameters and concluded that, the defect such wrinkles does not depend on die radius and fracture limit slightly increases with die radius and punch radius [3].

This paper aims at

1) To study the effect of die radius and blank holding force for different thicknesses on the defects like wrinkles and thinning during sheet metal single stage drawing of cylindrical cup.

2) To optimize tool parameter (die radius) and process parameter (blank holding force) to reduce wrinkles and thinning for different sheet thicknesses.

3) To conduct virtual experiments using FEA and compare the results with component produced at actual for different parameters.

2. PROCESS METHODOLOGY

Component drawing:

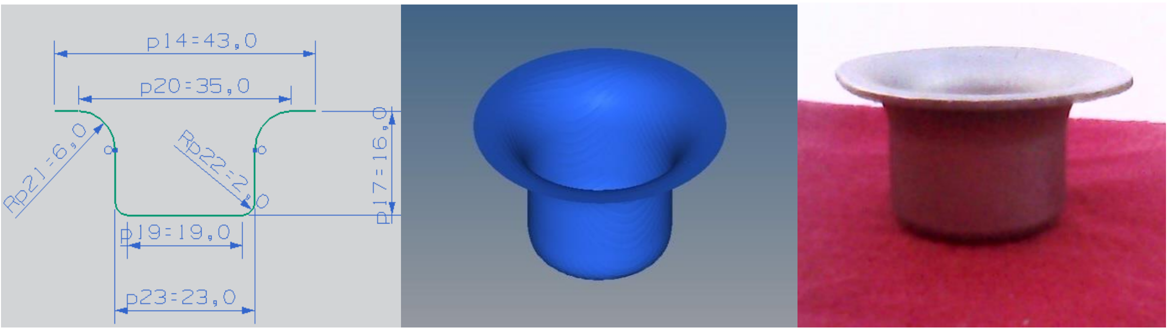

Figure 1: Component details and drawing - solid model and actual component Material

The material of the component is CRCA (Cold Rolled Closed Annealing) Drawn Quality (DQ) Steel And Thicknesses of the material considered as 0.5 mm, 0.75mm, and 1 mm.

Material Properties	Value
n value	0.22
r value	1.6
Hardness (HRB)	40

Remark: The checked parameters of given sample conforms to “D” grade as per IS 513-1994

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The sheet metal drawn component mostly found wrinkles (Fig.3.3.a) and thinning (Fig3.3.b), these defects mostly depend on different parameters. These parameters are divided as process parameters and tool parameters as listed below

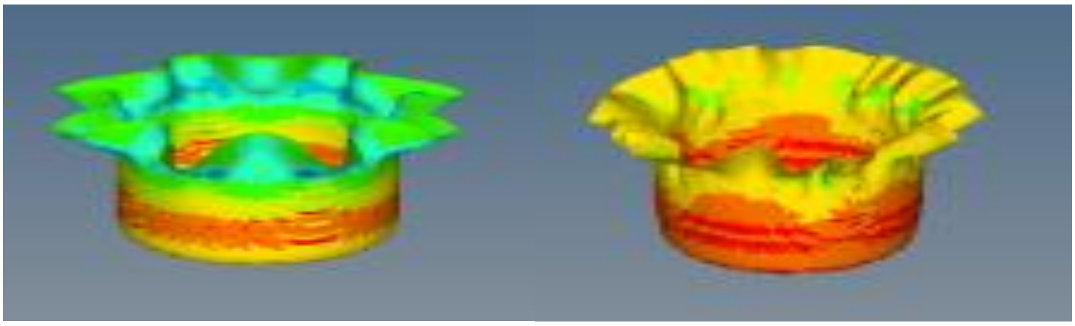


Fig 2.a **Fig 2b**

Figure 2: Defects in component

Virtual Experiment:

For study consider process parameters are 1) Die entry radius i.e. 2mm, 4mm, 6mm. 2)Blank holding force i.e. 1000N, 1200N, 1400N of different blank thickness i.e. 0.5mm, 0.75mm, 1mm.This parameter considering for simulation experiment.

Die set dimension:

All the dimension of Die set component are shown in fig.

Fig 3: (a) sheet model of Die set Dr2 (b) sheet model of Die set Dr4 (c) sheet model Die set Dr6 Blank development Developed in FEA Process

The solid model of the components is modeled using a CAD Unigraphics and exported this model in IGES forma

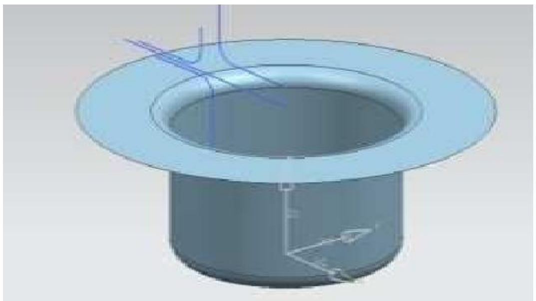


Figure 4: Solid model component

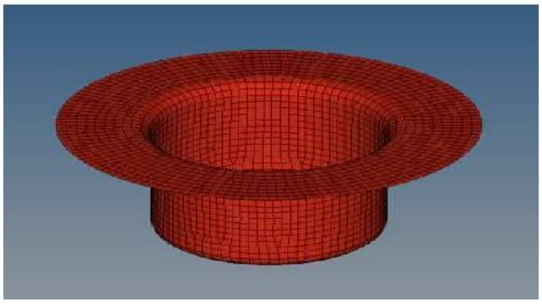


Figure 5: Mesh Component

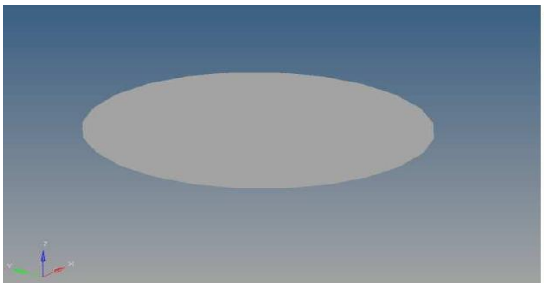


Figure 6: Blank development

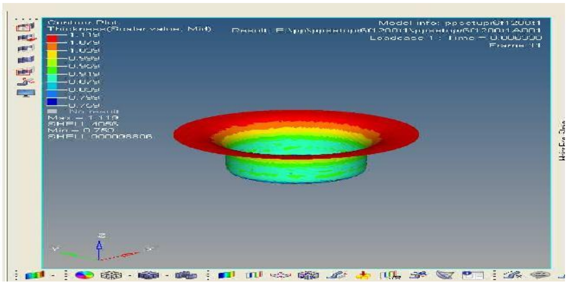
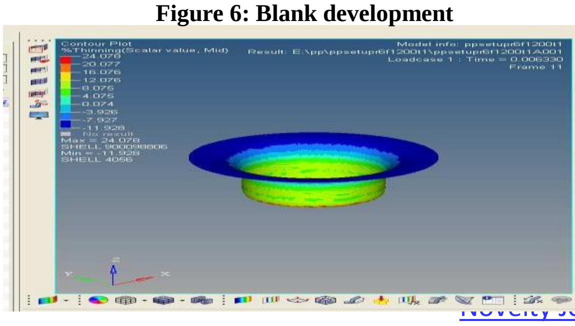


Figure 7: %Thinnin



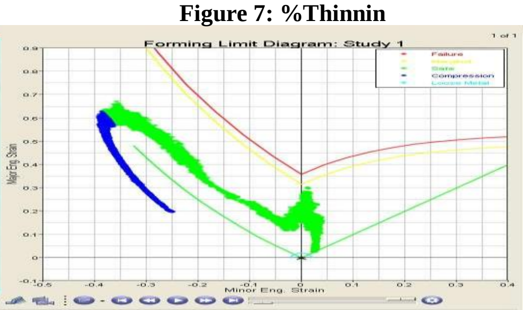


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Figure 8: Formability Analysis

Auto Process:

Auto process has two major steps: Setup and Detail. In setup select analysis type, and specify the essential input parameters for the analysis, in the fields that are available in dialog. The blank and tools of forming process have fields to fill in different values for each of these. After providing required data click Auto Position button to automatically adjust the position of tools. Apply button saves the current tool and blank settings, generate the load curves and input the files for RADIOSS solver. After the process is defined, it can verify that tool motion is correctly defined by reviewing animation control. In Detail review the setup and make modifications to input data. In Auto process, position the die, punch, binder, and blank by selecting Double Action Draw. Select input for draw beads, constraints, draw direction and motion type. Verify that the file type is source column next to Blank1, Die, Punch and Binder is HF. Click on Auto position button. Review Blank, Die, punch and binder parameters. Apply the parameters and review the animation control. Animation control field makes it possible to verify that motion is setup correctly. Save the file and Run the analysis.

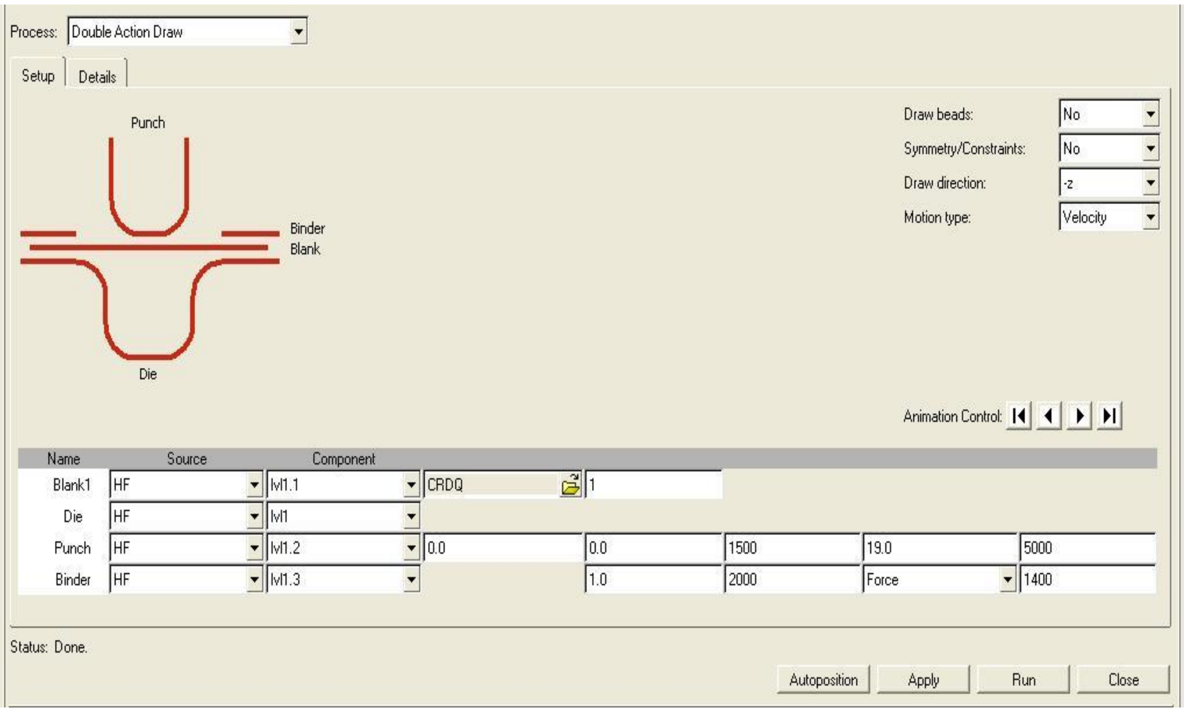

Figure 9: Auto process setup

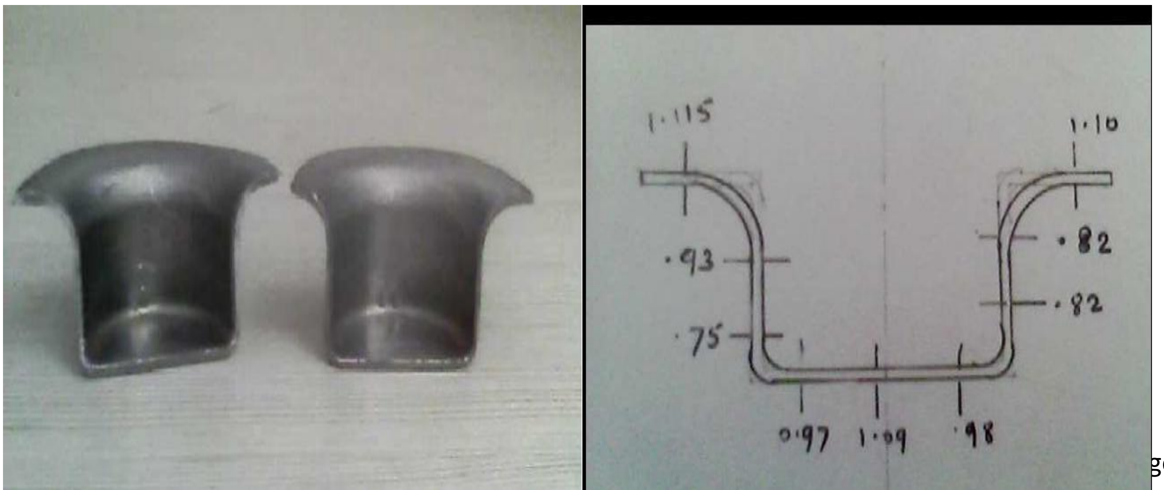

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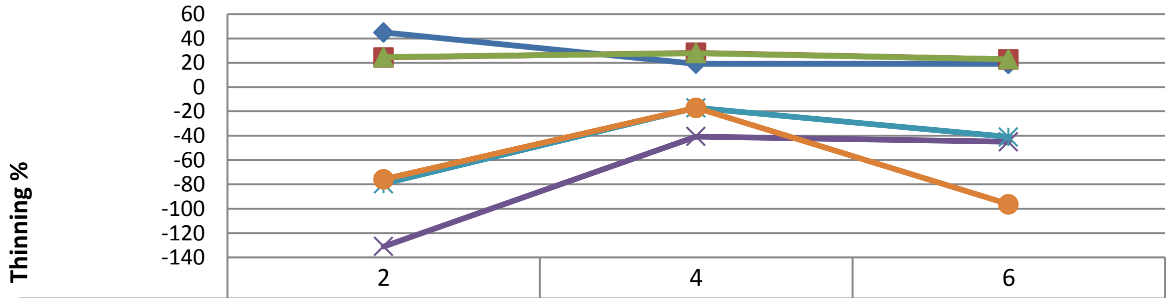
Figure 10: cut pieces of drawn component **Figure 11: measuring thinning % of cut piece**

3. RESULTS & DISCUSSIONS

Result of virtual experiments, on different process parameter i.e. Different Die entry radius and BHF at different blank thickness by software are as follows.

Influence of process parameters on thinning %:

A) Die entry radius:



	2	4	6
max.th.1000	44.83	19.12	18.98
max.th.1200	24.32	28.15	22.72
max.th.1400	24.59	27.79	22.87
min.th.1000	-130.9	-40.66	-44.95
min.th.1200	-79.47	-17.02	-40.99
min.th.1400	-75.71	-17.02	-96.24

Figure 12 Effect of die entry radius on thinning % at different BHF of blank thickness 1 mm

From figure 12, it is found that maximum thinning % on Die entry radius 2, with BHF 1200 N and minimum on Die entry radius 4, with BHF1000 N at blank thickness 1 mm& that minimum thinning % on Die entry radius 2, with BHF 1000 N and maximum on Die entry radius 6, with BHF1400 N at blank thickness 1 mm. But for better result consider minimum maximum thinning % and maximum minimum thinning % so better value of thinning % are 21.93 and -11.9. So it is concluded that when die entry radius increase, then maximum thinning % reduce up to Dr 4, and again increases up to Dr 6 and minimum thinning % increases up to Dr 6 at blank thickness 1 mm.

B) Blank holding force:

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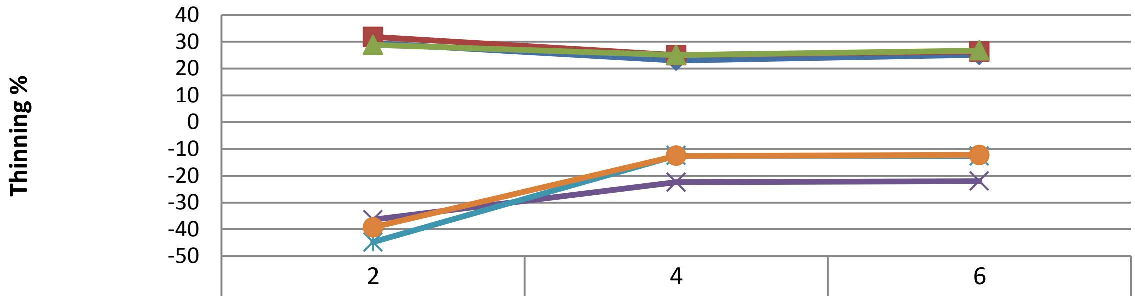
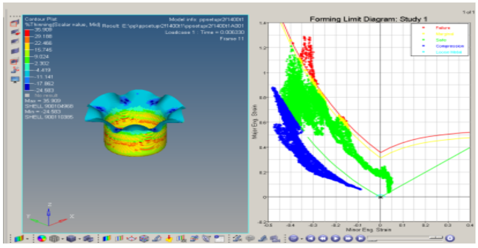
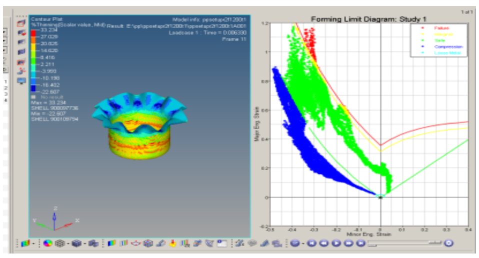


	2	4	6
max.th.1000	29.44	22.95	25.1
max.th.1200	31.81	24.97	26.32
max.th.1400	28.81	25.06	26.71
min.th.1000	-36.42	-22.44	-21.99
min.th.1200	-44.78	-12.47	-12.62
min.th.1400	-39.3	-12.6	-12.28

Figure 13: Effect of BHF on thinning % at different die entry radius of blank thickness 1 mm

From figure 13, it is found that maximum thinning % on BHF 1200 N, with Die entry radius 2 and minimum on BHF1200 N Die, with entry radius 4 at blank thickness 1 mm & minimum thinning % on BHF 1000 N, with Die entry radius 2 and maximum on BHF1400 N, with Die entry radius 6 at blank thickness 1 mm. But for better result consider minimum maximum thinning % and maximum minimum thinning % so better value of thinning % are 21.93 and -11.9,and a) when BHF increases, then maximum thinning % increases up to 1200 N and again reduces up to 1400 N & minimum thinning % continue increases up to 1400 N, at Die entry radii 2 with blank thickness 1mm b) When BHF increases, then both maximum thinning % & minimum thinning % are increase up to 1400 N, at Die entry radii 4 with blank thickness 1 mm. c) When BHF increases, then maximum thinning % increases up to 1200 N and again reduces up to 1400 N & minimum thinning % decreases up to 1200 N, and increases up to 1400 N, at Die entry radii 6 with blank thickness 1

Comparison of FEA result and actual result:

Parameters	Software component	Actual component
Die entry radius 2mm,BHF 1000N, Blank thickness 1mm		
Die entry radius 2mm,BHF 1200N, Blank thickness 1mm		

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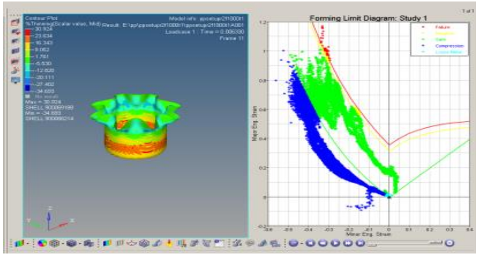
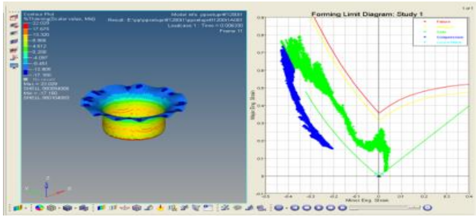
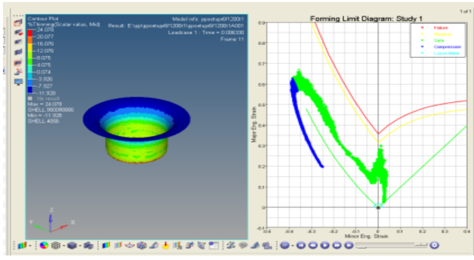
Die entry radius 2mm,BHF 1400N, Blank thickness 1mm		
Die entry radius 4mm,BHF 1200N, Blank thickness 1mm		
Die entry radius 6mm,BHF 1200N, Blank thickness 1mm		

Figure 6.Comparisons of software component and actual component

4. CONCLUSIONS

It is a finite element analysis based simulation has been done using Altair Hyper Form for the single stage drawing processes. The effect of parameters on the wrinkles, thinning and formability quality characteristics of Single stage drawing process has been done.

1) The virtual and actual experiment shows that, the wrinkles and thinning can be controlled by optimizing the die radius and blank holding force.

2) As the die radius increases the defect like wrinkles in combination with thinning reduces for optimized value of blank holding force for different sheet thicknesses.

3) The Altair's Hyper Form simulation software is used for virtual experiment and found to easy tool for sheet metal formability analysis. The actual experiment result confirms the result simulated using Altair Hyper form. From the simulation performed it is concluded that, defects wrinkles and thinning % can be control by varying die entry radius, blank thickness, and blank holding force.

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