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Development of a Sheet-Metal Component with a Forming Die Using CAE Software Tools (Hyper form) For Design Validation and Improvement

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ABSTRACT: *Sheet-metal die is an inseparable constituent of the development process of any given automotive or consumer appliance. In most of the cases, this accounts for a high proportion in the tooling needs of the large size and structural member in any automotive like the chassis and the BIW. Many other brackets and gussets along with peripheral clips etc are invariably made of Sheet-metal due to the strength characteristics complimented by this material and the process of stamping.*

Keywords: *Blank holding Force, Die block, Forming Die Design, HYPERFORM, Punch.*

I. INTRODUCTION

Sheet metal forming is one of the most commonly used processes in industry. Throughout the years, the sheet metal forming industry experienced technological advances that allowed the production of complex parts. However, the advances in die design progressed at a much slower rate, and they still depend heavily on trial-and-error and the experiences of skilled workers. During the development of the Die, a reduction in the number of trials would directly influence the cycle time for development. A shorter cycle time can be planned with due utilization of software tools that would predict the trial results without actually conducting the same. The simulation offered by the software during the process of stamping lends important insights into the modifications needed in the die and/or the component to effect a simplified and productive die. Normally, a Forming die (including Draw die) calls for refined design parameters for ensuring a smooth passage through the trial phase of the developed Die normally accompanied by crucial review inputs over the design of the component too. The study of the papers offers enough inputs to take up the project work in identifying a `process-oriented' solution that could be used as a reference for academicians and the corporate entities while faced with the challenges associated with the elusive process of `Forming'

II. Sheet Metal Forming Process

Sheet metal forming processes are the complex interaction between specimen (geometry, tolerance, surface topology, etc.), the forming process (tooling, forming machine, force, lubrication, etc.) and the material (ductility, material parameters, microstructure, corrosion resistance, residual stress, etc.) which exist in forming processes. Most problems in sheet metal forming come from a bad control of holding, restraining and spring back.

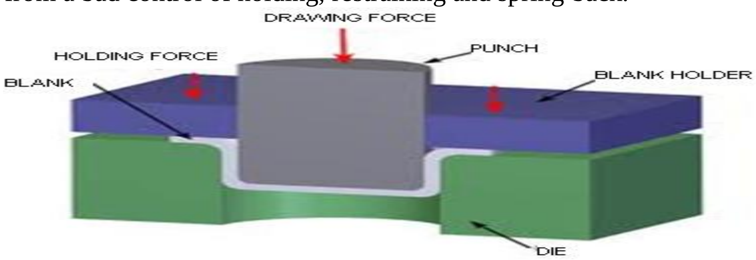


Figure 1.1: Schematic Diagram of Forming With Punch and Die

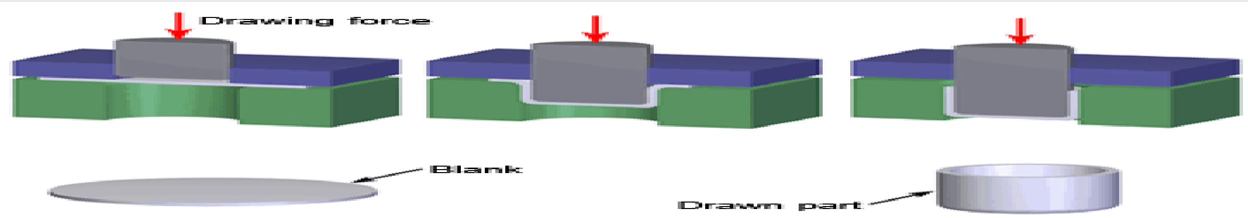


Figure 1.2: Schematic Diagram for the stages of `Forming' process

Geometrical defects in sheet metal forming: The Forming or deep drawing process allows the production of large quantities of sheet metal parts of various complexities. During the process a piece of sheet metal is clamped between the die and the blankholder. A force is applied to the blankholder to prevent wrinkling of the sheet and to control the material flow during the deformation. When the punch is pushed into the die cavity the sheet deforms plastically and thereby it takes the

specific shape of the tools The quality of the final product shape is determined by the tools design, process parameters, shape and material of the blank. It is important to carefully consider all these factors prior to manufacturing; otherwise a defective product could result. Typical defects which are observed in sheet metal forming practice are wrinkling, necking and subsequent fracture, drawing grooves. In addition to these defects, there is also always geometrical distortion caused by elastic springback. Right after forming, the shape of the deformed product closely conforms to the geometry of tools. However, as soon as the tools are retracted, an elastically-driven change of the product shape takes place.
The attempt of this work would also be to minimize the defects evident during the development phase of the component.

III. Die Design Calculations

The component chosen for this dissertation would is derived from the projects being undertaken by the sponsoring company- Able Technologies (India) Pvt. Ltd., Pune. The case study shall incorporate the design and development of the component named - `Cup' that is used over the subassembly of a popular two wheeler mounting bracket.

III.1 The specs along with the drawing for this component are given below:
Component Name –Cup
Material – CRCA Steel EDD Grade as per IS513-1994
Thickness – 1.00 +/- 0.03 mm

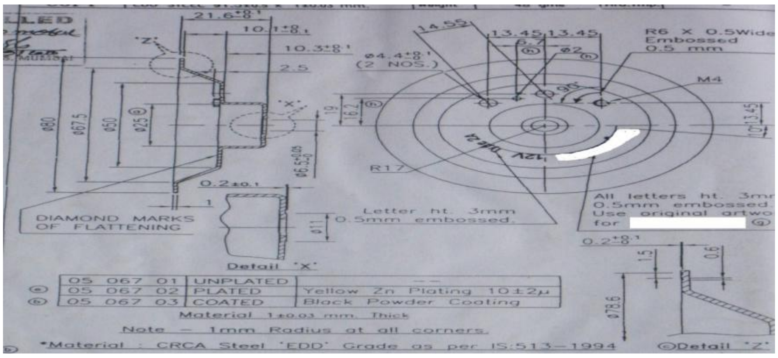


Figure 2: Extract from the part drawing for the component

III.2. Developed Blank Diameter = 112 mm. (radius at each step ignored for sake of simplicity since the component is not required to mate in the assembly and the function does not call for precise control over the flange diameter)

III.3. Draw Ratio – At this component, the Draw = H/d = 20.6/67.5 = 0.31 which indicates the draw is simple & may require only one stage for completion.

III.4. Draw Force – Draw Force can be calculated by empirical relation,
P = . d. t. s. ((D/d) – C)
Where, P = Draw Force in Tons
D = Blank Diameter in mm = 112 mm
d = Punch Diameter in mm = 25 mm
t = Thickness of Metal in mm = 1.00 mm
S = Yield strength of Metal in Kg/mm^2 = 40 Kg/mm^2
C = Constant (Take 0.6 to 0.7)
We know that,
P = . d. t. s. ((D/d) – C)
P = π x 25 x 1 x 40 x ((112/25)-0.6)
P =12183.2 Kg
P =12 Ton
Factor of safety should be taken 1.25,
Therefore, Draw Force (P) = 12 x 1.25 = 16.25 ≈ 17 Ton

III.5. Die Block Dimension –
Diameter = ø165 mm
Material for Die block should be use HCHCr & OHNS
Hardness – Die Block should be harden upto 60 to 62 HRC

III.6. Top Plate – Top Plate Dimension = 320 mm x 250 mm
Thickness for Top Plate should be 32 to 35 mm (Take 35 mm)
III.7. Bottom Plate – Bottom Plate Dimension = 400 mm x 250 mm
Thickness for Bottom Plate should be 22 to 25 mm (Take 25 mm)

III.8. Punch Height – Height for Punch should be 69.1 mm

III.9. Draw & Punch radius – The Draw radius usually ranges from 4 to 10 times the Blank thickness,
Therefore, Radius of Draw Die = Rd =4.5 x 1 = 4.5 mm
The Punch radius usually ranges from 3 to 4 times the Blank thickness,
Therefore, Radius of Punch = Rp =3 x 1 = 3.0 mm

III.10. Shut Height – The Shut Height of the unit shall be,
H = Die thickness + Lower shoe thickness + Punch Height + Punch Plate thickness + Upper shoe thickness – Penetration of Punch in Die = 45 + 25 + 69.1 + 29 + 35 – 3.1 = 200 mm.

III.11. Blank Holding Force – Blank Holding Force (B.H.F.) is always 30 % of Draw Force, therefore B.H.F. can be calculated as, Blank Holding Force (B.H.F.) = 30 % of Draw Force
= 30 % x 17 = 5.1 Ton ≈ 5.0 Ton
Material for Blank Holder should be use EN-353 or 20MnCr5
Hardness – Blank Holder should be harden upto 30 to 35 HRC

III.12. Press Tonnage or Press capacity –Press Tonnage can be calculated by using following formula,
Press Tonnage = Draw Force + Blank Holding Force (B.H.F.)
= 17 + 5 = 22 ≈ 25 Ton
Therefore, Press Capacity of 25 Ton shall be suitable.

IV. FIGURES AND TABLES

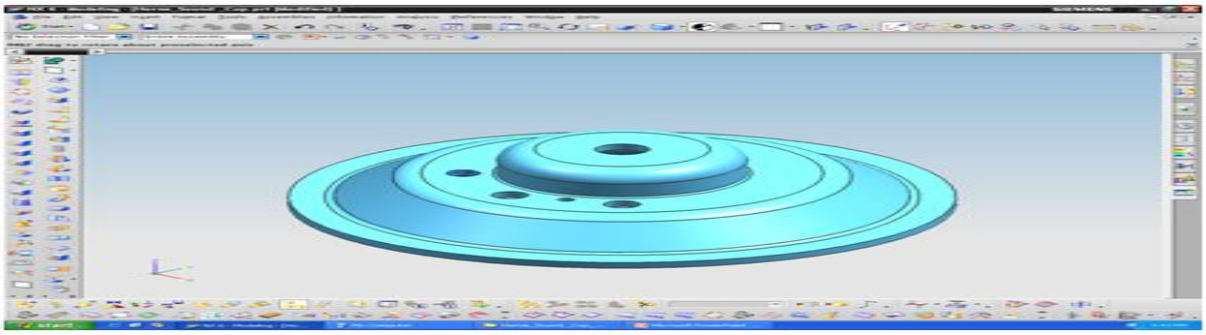
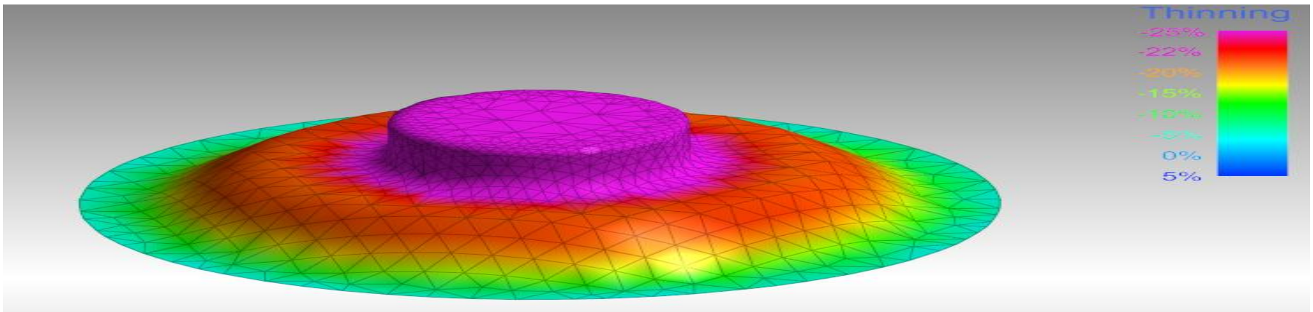


Figure 3: Solid model of the component (Cup) using CAD software `Unigraphics NX-6'



Analysis of component (Cup) using CAE/Simulation software `HYPERFORM'
Figure 4.1: Result of Analysis for Blank holding force at 5 Ton
Observation: Maximum thinning recorded – 25% of the thickness of the component (acceptable part quality)

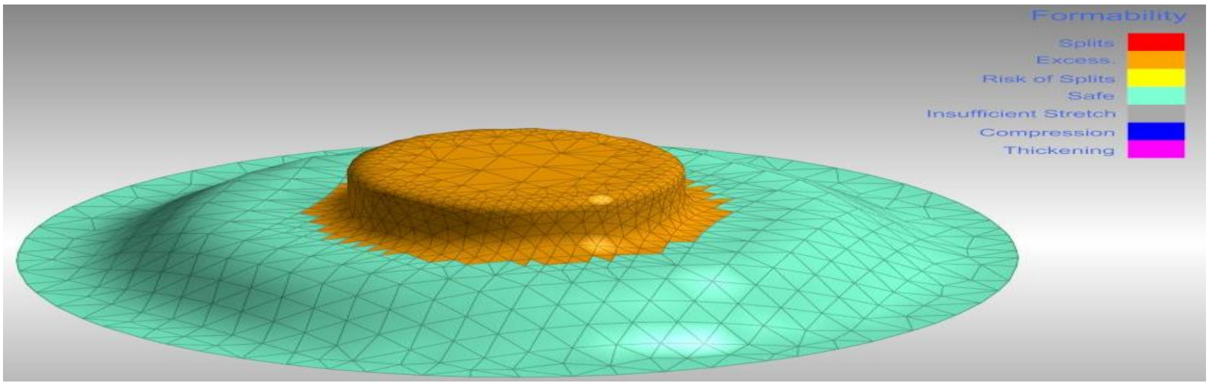


Figure 4.2: Result of Analysis for `Blank holding force' at 5 Ton
Observation: No splits or any major defects observed (acceptable part quality)

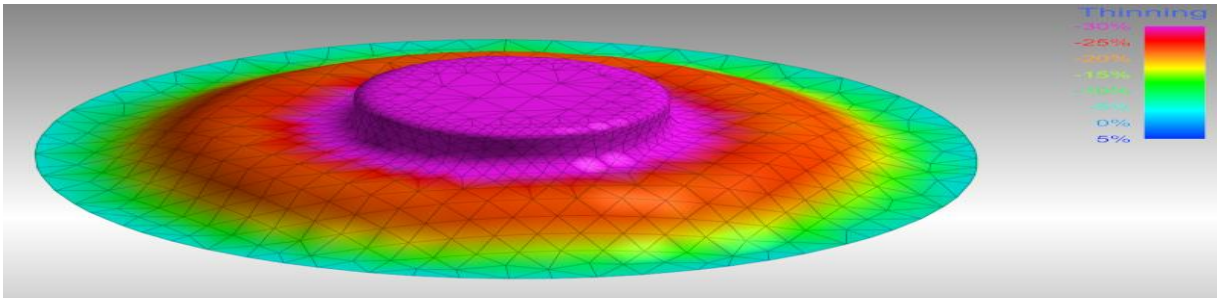


Figure 4.3: Result of Analysis for Blank holding force at 10 Ton

Observation: Maximum thinning recorded – 30% of the thickness of the component (unacceptable part quality)

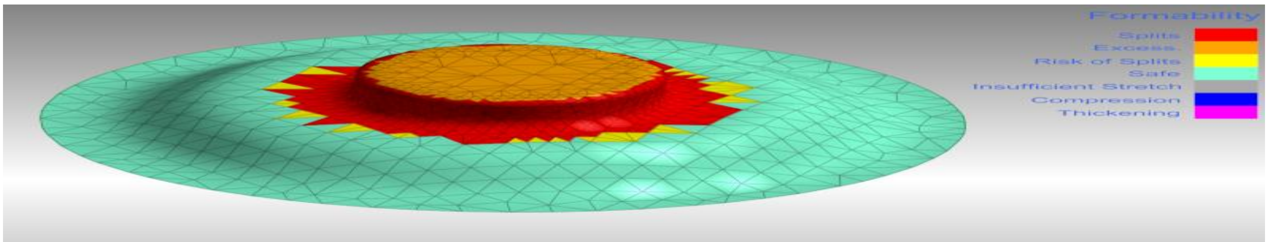


Figure 4.4: Result of Analysis for Blank holding force at 10 Ton

Observation: Large region exposed to the tendency for splits (unacceptable part quality)

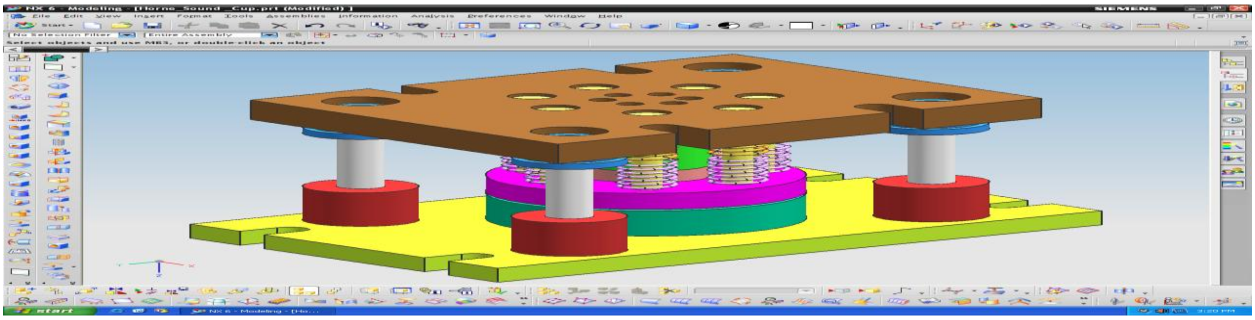


Figure 5: Solid model of forming die for component (Cup) by using Unigraphics NX-6

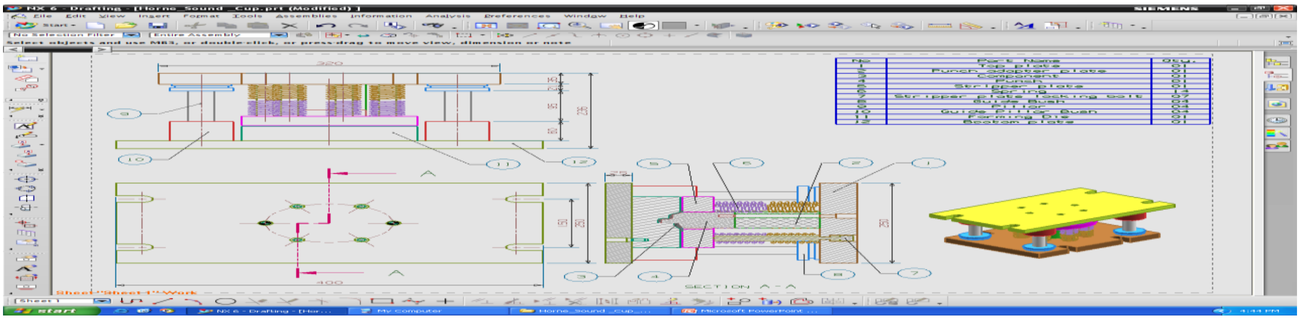


Figure 6: Schematic sketch of forming die for component (Cup) by using Unigraphics NX-6

V. CONCLUSION

Sufficient research and deliberation using the proven QC tools backed up with CAE software support (HYPERFORM) has offered a feasible solution to the problem at hand. Steel material like HCHCr (High carbon High Chromium) & OHNS (Oil Hardening non Shrinkage) grade for both punch and die block to suit the components having EDD (Extra Deep Draw) is recommended per the practices found in the industries. The operating condition involving the magnitude of blank holding pressure is varied and the results analyzed. Thinning and Formability are ascertained in this study. For finding the range of load at which the thinning or formability is unacceptable, the iteration for analysis with a blank holding force of 10Ton was applied and the results recorded as per figure 4.3 & 4.4. Suitable blank holding pressure (5Ton) is recommended for a defect-free component as per figure 4.1 & 4.2. The results obtained by mathematical treatment and the results obtained through the use of software (analytical) agree reasonably well. These results also establish generic guidelines for forming die design for Extra Deep Draw (EDD) materials. In order to expand the range of application of the developed method, parts with more complex geometries can be considered as future scope of work.

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