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DESIGN AND ANALYSIS OF DEEP-DRAW DIE COMPONENT FOR IMPROVEMENT IN HORN CUP

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Abstract
Items often made by deep drawing include cupped baking pans, like muffin pans, and aluminum can cylinders. However, irregular items, like fire extinguishers and enclosure covers for oil filters in trucks are also made this way - as is your kitchen sink. Products made by deep drawing are deep and seamless. The finished shape produced by a drawing press depends on the position in which the blanks are pushed down. Only malleable metals that are very resistant to damage by tension and to stress can be used in this process. Industries where deep drawing is often used include the dairy industry, pharmaceuticals, plastic manufacture, and the auto industry, aerospace and lighting. Companies making parts by deep drawing need expensive presses and operations put together by trained engineers, as well as plates, molds, and other accessories. Unlike metal stamping, deep drawing uses a single piece blank, not a continuous stream of blanks. The productivity of the stamping process in the industry yields better quality product at an economic price. The dissertation work is relevant in the context of developing a cost effective die with a lower lead time through the phase of Design, Development, Trials and Testing, Pilot lot production & amp; Regular supply. The Deep draw process being critical to evaluate offers higher scope for study and research while addressing the most suitable design for the Draw Die. Achieving high standard quality products in almost no time with great economy in automobile industry demands for a technology that helps exceed the engineering requirement of products. This research highlights the advantages of using Altair’s Hyper Form using RADIOSS to design drawing tools like die and punch for one of the automobile components along with the procedure of required blank shape. Hyper- form help reducing the complete product development cycle to almost less than 40% of what it usually took using conventional methods. Lesser effort and easy to model the complete set up important features with different design parameters, improved the product development without compromising quality. The challenge was to develop the wrinkle free component restricting percentage thinning to 20%. Different design iterations were carried out to get the best possible product in minimum time. Design changes where done in the existing die design to make it cost and time effective by saving workmanship involved in its development. Simulation revealed the need of optimizing the blank apart from die modification, to get rid of the wrinkles.
Keywords: Wrinkles, Forming, Blank holder.

I. Introduction

Metallic stamping talk about to the course of shaping and cutting metals into certain forms, and is usually used in producing components for arrangements or huge fragments of technology. Steel, titanium, Zinc and aluminum are between the most collective metals used for this purpose. Metallic stamping is well known as a cost effective mode to produce tons of altered items on a huge scale. [2]
Deep drawing is also a course of forming sheet metal through a forming die with a punch. Metal in the area of the die shoulder experiences a lot of stress, and will effect in wrinkles if a blank holder is not used to governor the flow of material into the die. Material is typically thickest in the area wherever the metal mislays interaction with the punch, the punch radius besides thinnest in the areas wherever stresses are extreme. Deep drawing is often used to produce metal objects that are additional than partial their diameters in height. The metal is pushed near by a plug, and then enthused into the die. [2, 4]

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Items often complete by deep drawing include cupped baking pans, resembling muffin pans, and aluminum can cylinders. However, unequal items, comparable fire extinguishers and enclosure covers for oil filters in trucks are similarly ready this way - as is your kitchen sink! Products finished by deep drawing are deep and seamless. The finished shape formed by a drawing press depends on the situation in which the blanks are strapped down. Only malleable metals that are actual impervious to destruction by tension and to stress can be used in this progression. [1]

The productivity of the stamping progression in the industry produces enhanced quality product at an economic value. The research work is relevant in the context of developing a cost effective die with a lower lead time concluded the phase of Design, Development, and Trials as well as Testing, Pilot lot manufacture& Regular resource. The Deep draw progression being critical to assess offers advanced choice for study and research while addressing the most appropriate design for the Draw Die. [3, 4]

1.1 Die set and its details

The whole die set entails of a punch, die and certain other accessories which are defined in this sector future. Perfect orientation of punch and die is most significant for agreeable working of punch. Accessories of die set offers the necessitate arrangement and firmness to the arrangement and expands exactness of the arrangement routine. These accessories are the finished parts, removal of waste. The die accessories are Punch, Lever Stop, Punch Holder, Die Holder, Backing Plate, Pilots, Pressure Pads, Punch Plate, Stops, Bottom Top, Strippers, Knockouts, Guide Posts, and Die Retainer etc. [4]

1.2 Important Consideration for Design of a Die Set

Important facts should be considered while designing a die set is recorded beneath:

(a) Cost of manufacturing is contingent on the lifespan of die set, so choice of material should be done cautiously keeping strength and wear resistant properties in observance.

(b) Die is generally hardened by heat treatment so design should billet all precautions plus allowances to incredulous the ill belongings of heat treatment.

(c) Accuracy of production finished by a die set unswerving lyres to the accuracy of die set mechanisms. Design should be attentive on upholding precise dimensions and close-fitting tolerances.

(d) Lengthy thin sections should be changed by block shaped sections to escape war -page.

(e) Standardized mechanisms should be used as much as possible.

(f) Reinforcing grips should be used as per the necessities of the sections.

(g) Stress-free maintenance should be reflected. Replacement of parts should be easy.

(h) The method should be shock proof, if it is inevitable, shock resistant properties should also be cogitate while selecting the material of components of die set.

II. Literature

Arash Behrouzi, Bijan Molaee Dariani, Mahmood Shakeri [1] have conferred Shape blunder due to elastic regaining of shaped part in unloading known as spring back, is one of the utmost imperative problems of tool design in sheet metal forming processes. These approaches are usually based on iterative finite element algorithms. In this paper an analytical approach is obtainable for one step modification of the tooling profile in channel making process to recompense the spring back error. The outcomes of the analytical method correspond with those of FE approach.

Juraj HUDAK, Miroslav TOMAS [2] had existing contribution deals with force parameters research (drawing besides blank holding) in deep-drawing progression of flat bottomed cylindrical cup. Experimental research was understood using steel sheets for enameling KOSMALT produced by U.S. Steel Košice, Ltd. Deep drawing development of this steel is complex due to contradictory requirements from the interpretation of steel configuration good draw capability and good enameling.

Hakim S. Sultan Aljibori, Abdel Magid Hamouda [3] had done the study on Minimization of retort times and costs and intensification of the efficiency and quality in creating a product are imperious for persistence in the competitive manufacturing industry. LUSAS simulation was conceded out to gain true and perilous thoughtful of sheet forming process. Ax symmetric element mesh and plain strain element mesh were use incorporated with slide line structures to model and study the sheet metal forming process. Simulation of elastic plastic comportment of aluminum sheet was carried out under non-linear state to investigate sheet metal forming process.

J. S. Colton,Y.Parkhas [4] debated the claim for rapid, low-cost die fabrication and alteration technology is superior to ever in the sheet metal forming industry. One category of rapid tooling technology includes the use of advanced polymers and composite materials to fabricate metal forming dies. Both computational and experimental approaches are employed to consider the accuracy of the standards and to recognize the dominant process bounds in V-die bending.

A.Wifi. &A.Mosalam [5] have discussed the intricacy and interactive flora of the strictures affecting the performance of several blank-holding practices. The present work is part of a research work that is presently in development under the direction of the senior author on the valuation and search for optimized BHF systems in deep drawing processes.

III. Problem Definition

The Sheet metal commerce is faced with a multitude of dares while developing a Tool (Die) for a forming or a Deep Draw operation. The operation is precarious in nature and calls for high capability on the fragment of Design as well as the material and the process aspects.

3.1 WRINKLING

1) Compressive uncertainty
2) Blank holder pressure too constricted
3) Draw radius too large
4) Disturbed blank holder pressure

3.2 TEARING

1) Material endures fracture.
2) Punch-die clearance too small
3) Very high BHF

3.3 FRACTURE

1) Draw radius and blank holding surface scratched.
2) Punch nose and draw radius too small.

3.4 THINNING

1) Uneven flow of material into the die cavity
2) Clearance between punch and die too little, too great or uneven.
3) Blank holder pressure too great.
4) Lubricant inadequate or unsuitable.

3.5 SPRING BACK

1) When the bending stress is impassive at the finish of the distortion, the material tends to recover its original shape. This is devoted to as `elastic recovery' i.e. the spring back
2) Here consider of aluminum material spring back is less it is negligible.

IV. Die Design and Modeling

4.1 Die design

1) Draw Force (P)

$P = \pi dts\ (D/d-c)$

P=Drawing Force

d=Punch diameter=25mm

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D=Blank diameter=112mm
t=Thickness of metal sheet=2.5mm
s=Yield strength of metal=14 kg/mm^2
C=constant based on friction =0.6 to 0.7
P= Pi [3.14] X small punch dia. (d) X thickness (t) X shear strength of Aluminum (s) X [(Blank dia. D / Punch dia. d) - Constant (c)]
P= 3.14 X 25 X 2.5 X 32 X [(112/25) - 0.65]
P= 25052 Kg OR 25 Tons
Add factor of safety as 1.25 (25%)
So total Draw Load = 25 X 1.25 = 30 Tons
Draw load is = 30 Tons

2) Material selection

Die Block= (Harder) HcHcr (60-62) HRC
Punch= as same Die Block
Blank Holder=20 M_n cr_5 (30-35) HRC

3) Blank Holding Force

Blank Holder load is usually 30% to 35% of draw load,
So it is = 30×.35 = 10.5 Tons

4) Press Selection

15 + 10.5 = 25.5
25 or 30 Ton mechanical press available

5) Cutting Clearance

For materials up to 3.2 mm thick
Since the material is Al, the clearance has to be very, small because Al is very soft in nature
Therefore clearance (c) = 0.01 – 0.015

6) Spring Selection

Stripper load required – 5000 kg (5 TON)
Travel needed – 10 mm
Gap Available bet blank holding and top plate = 102.5 mm
Extra Heavy spring needed so Darnley make catalogue used to find q – 2008 – 360
Free Length=51 mm, Pin dia. =16 mm, Hole dia. =32 mm
Load at 20 % compression at 10 mm to length = 352 kg
No. of spring needed = 5000/352 = 14 qty.
To reduce space requirement we can use 2 springs one on above
Therefore Fl = 51 + 51 =102 mm
At pre-compression 3 mm = 102 - 2.5= 99.5 mm
NOTE: - Loading 2 springs in series one above the other to reduce space requirements.
Therefore 14 springs needed by loading in series they would need 7 spaces/positions for location. As the springs are loaded in series total travel is 10 mm but load will get doubled/mm compression As the springs are loaded in series total travel is 10 mm but load will get doubled/mm compression.

4.2 Properties of Draw Component material- Aluminum 5052

Aluminum alloy 5052 contains nominally 2.5% magnesium & 0.25% chromium. It has well Workability, medium static strength, high fatigue strength, good weld ability and very good corrosion resistance, especially in marine atmospheres. It also has the low density and excellent thermal conductivity common to all aluminum alloys. It is frequently used in sheet, plate and tube form.
Typical Applications- Architecture, general sheet metal work, heat exchangers.

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Table 1- Chemical Composition

Element	%	Element	%
aluminum	balance	cooper	0.10max
magnesium	2.2-2.8	manganese	0.10max
chromium	0.15-0.35	zinc	0.10max
silicon	0.25max	Others each	0.05max
Iron	0.40max	Others total	0.15max

Table 2- Mechanical Properties

Temper	0.2%proof stress, mpa min	Tensile strength, mpa	Elongation %min
O (annealed)	65	170-215	14-20
H32	160	215-265	4-10
H34	180	235-285	3-8
H36	200	255-305	2-4
H38	220	270 min	2-4

Table 3- Physical Properties

Property	At	Value	Unit	Property	At	Value	Unit
Density	20 ^{0}C	2,680	Kg/m^3	Mean Coefficient of Expansion	20 ^{0}C	23.75	x 10-6 / ^{0}C
Melting range		607-750	^{0}C	Thermal Conductivity	25 ^{0}C	138	W / m. ^{0}C
Modules of elasticity				Electrical Resistivity	20 ^{0}C	0.050	micro-ohm. m
Tension	20^{0}C	69.3	GPa	Electrical conductivity			
Torsion	20 ^{0}C	25.9	GPa	Equal volume	20 ^{0}C	35	% IACS
Compression	20 ^{0}C	70.7	GPa	Equal weight	20 ^{0}C	116	% IACS

4.2.1 Fabrication: -Aluminum 5052 is not commonly hot worked. It is very cheerfully cold formable in the annealed condition, as it is ductile. For piercing and blanking the punch to die clearance should be about 7% of the thickness per side for the H32 & H34 tempers.

4.2.2 Machinability: -5052 is gladly machinable by predictable methods. It should be machined at high speed with copious lubrication to avoid thermal distortion of the work piece.

4.2.3 Welding: -5052 is readily wieldable by usual techniques. It is commonly welded with GTAW (TIG) or GMAW (MIG). Aluminum essential be very dry & clean to avoid contamination & porosity of the weld.

4.2.4 Heat Treatment:-Aluminum 5052 is annealed at 345 ^{0}C, time at temperature and cooling rate are insignificant. Stress relief is rarely required, but can be agreed out at about 220 ^{0}C. If loss of strength is of concern, stress relief tests should be directed.

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4.3 Die Modeling

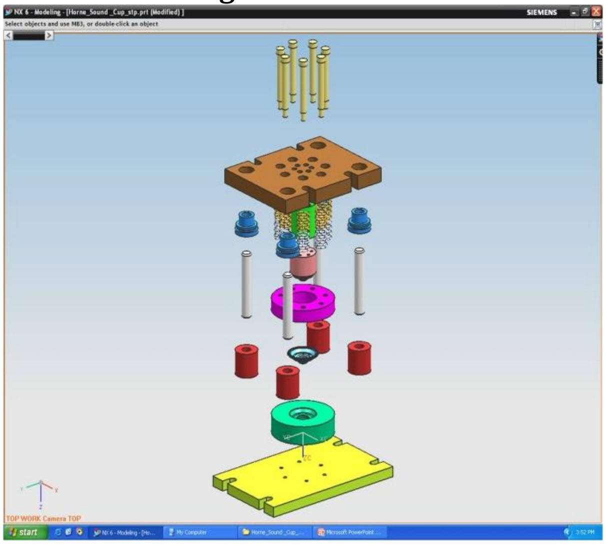

Figure 1: Assembly Model

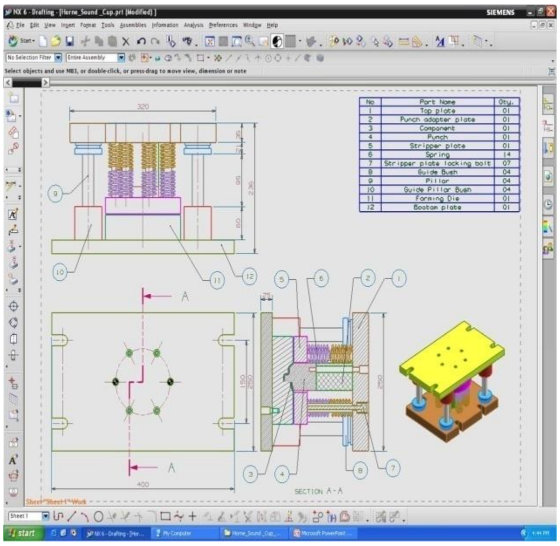

Figure 2: Assembly of 2-d die

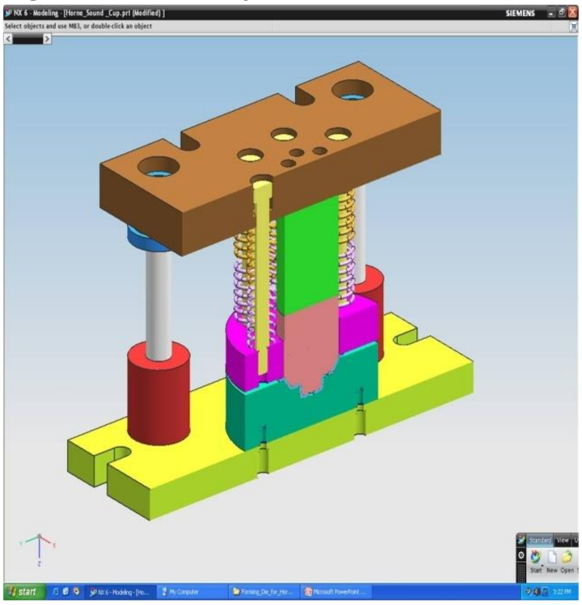

Figure 3: Final assembly of die

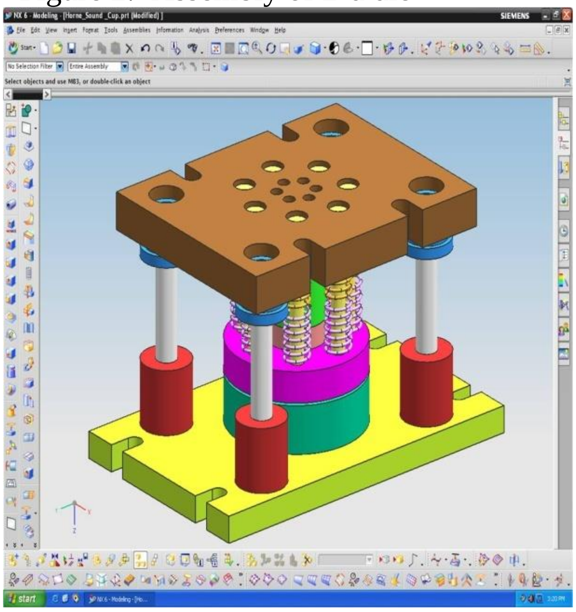

Figure 4: cut section of final assembly

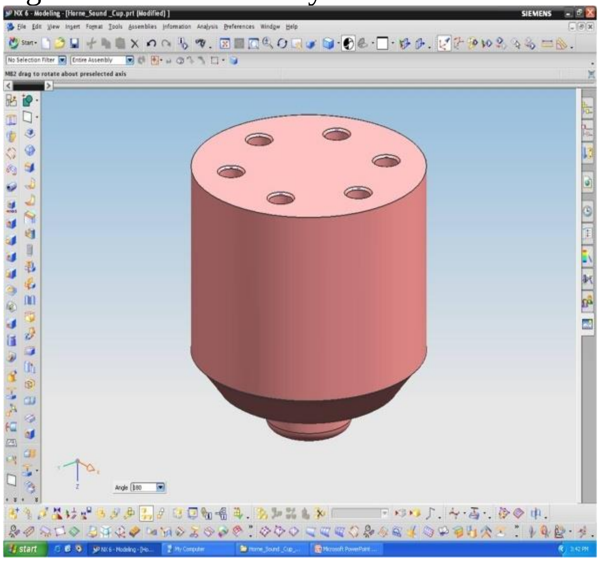

Figure 5: Modeling of punch bottom

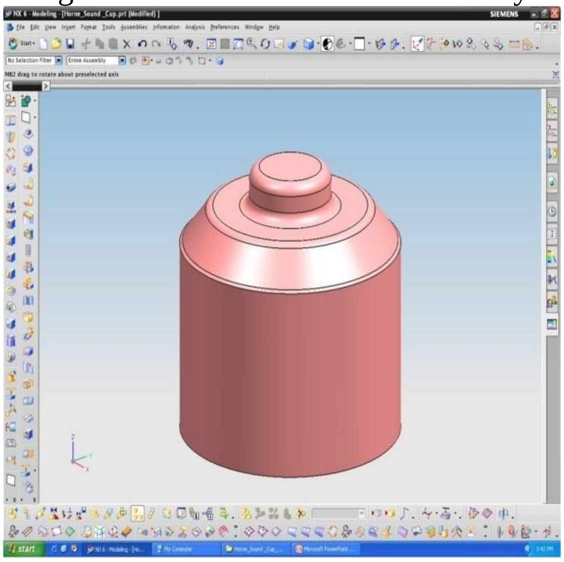

Figure 6: Modeling of punch top

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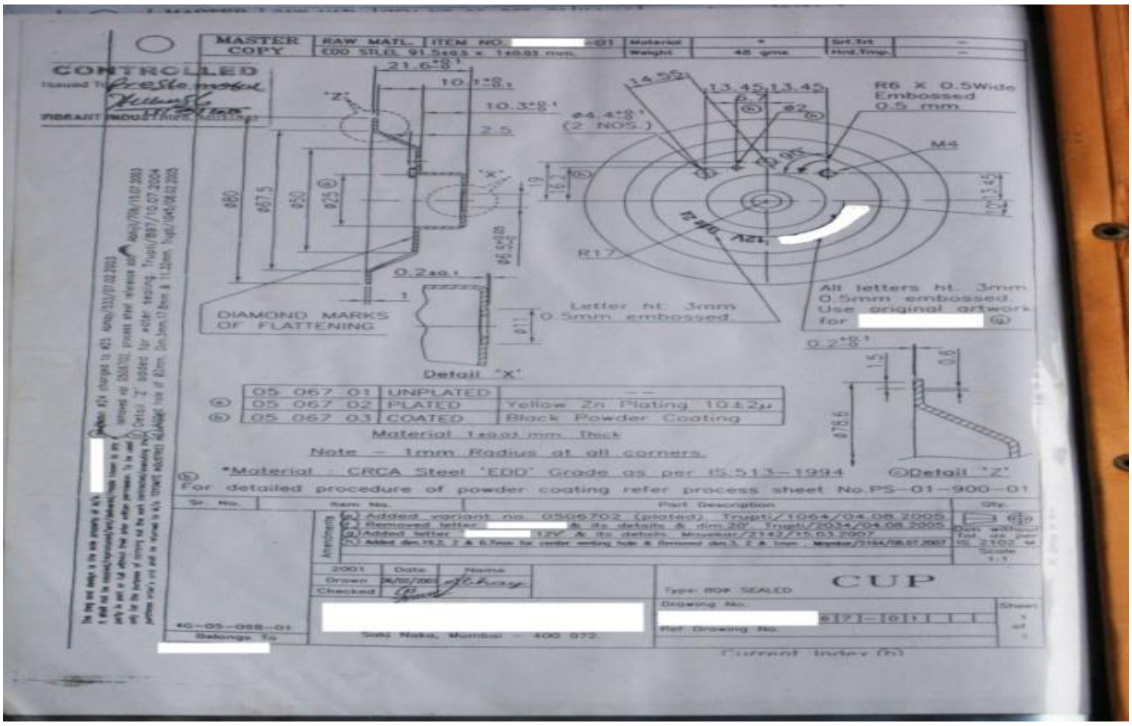

Figure 7: 2-D drawing of cup

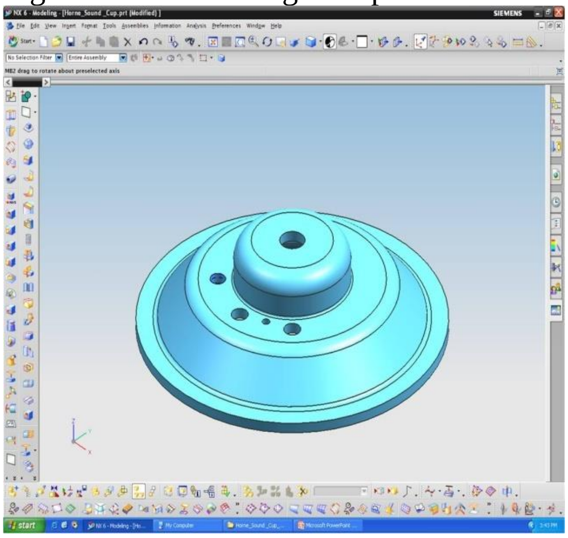

Figure 8: Modeling of horn cup Back

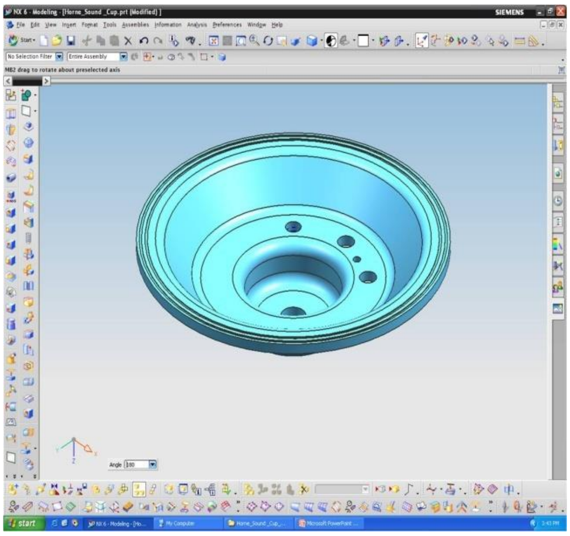

Figure 9: Modeling of horn cup Front

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V. Experimentation

5.1 Original component analysis

- Trial:1 **(** Material thickness 2.00 mm and BHF 20 Ton)

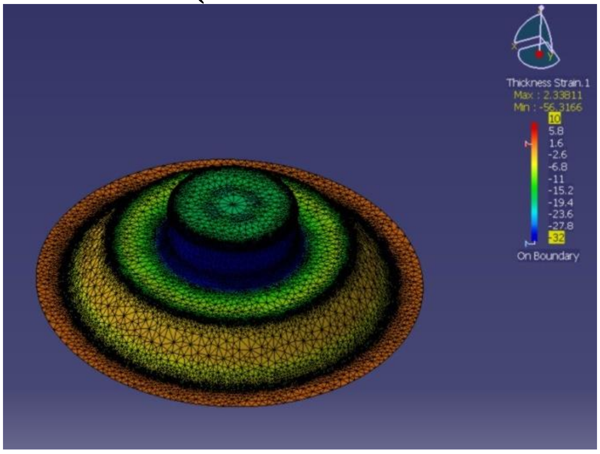

Figure 10: Formed component

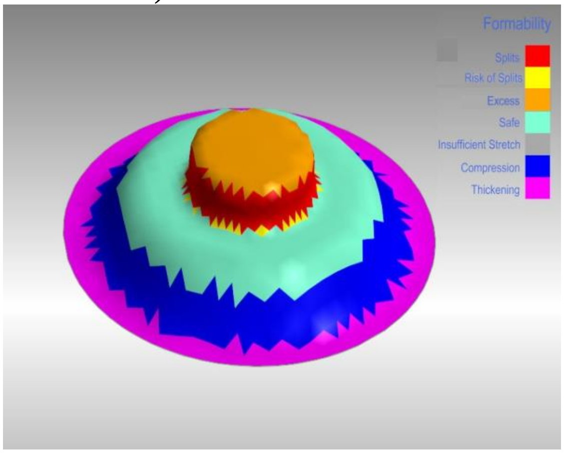

Figure 11: Component test

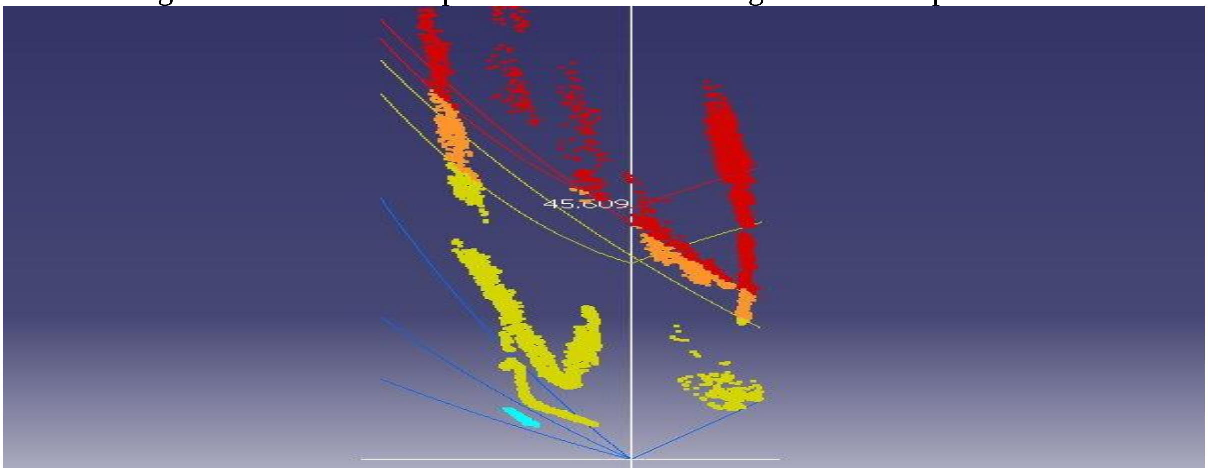

Figure 12: FLD Curve for 10 BHF Splitting was observed)

5.2 Modified component

- Trial 2(increased material thickness 2.5 mm and BHF 10 Ton**)**

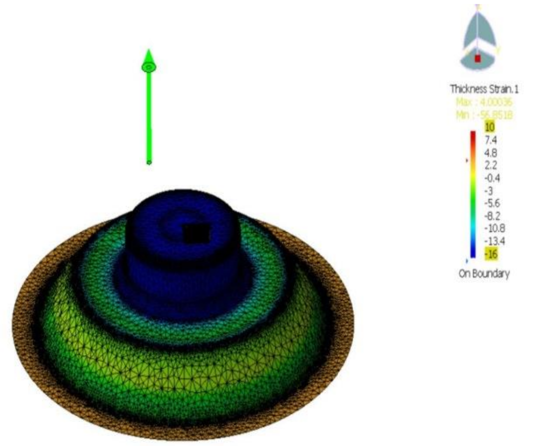

Figure 13: Formed component

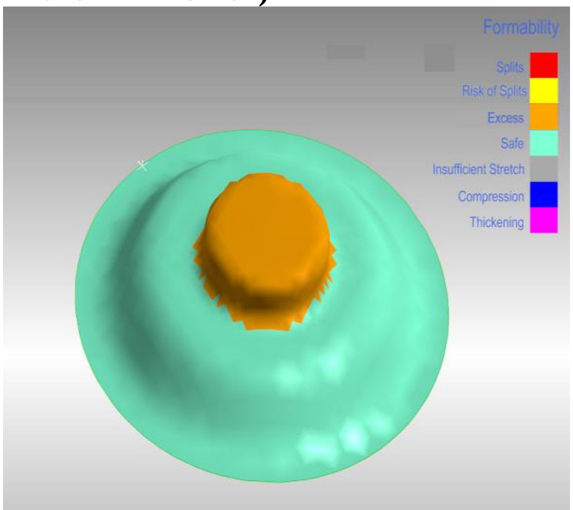

Figure 14: component test

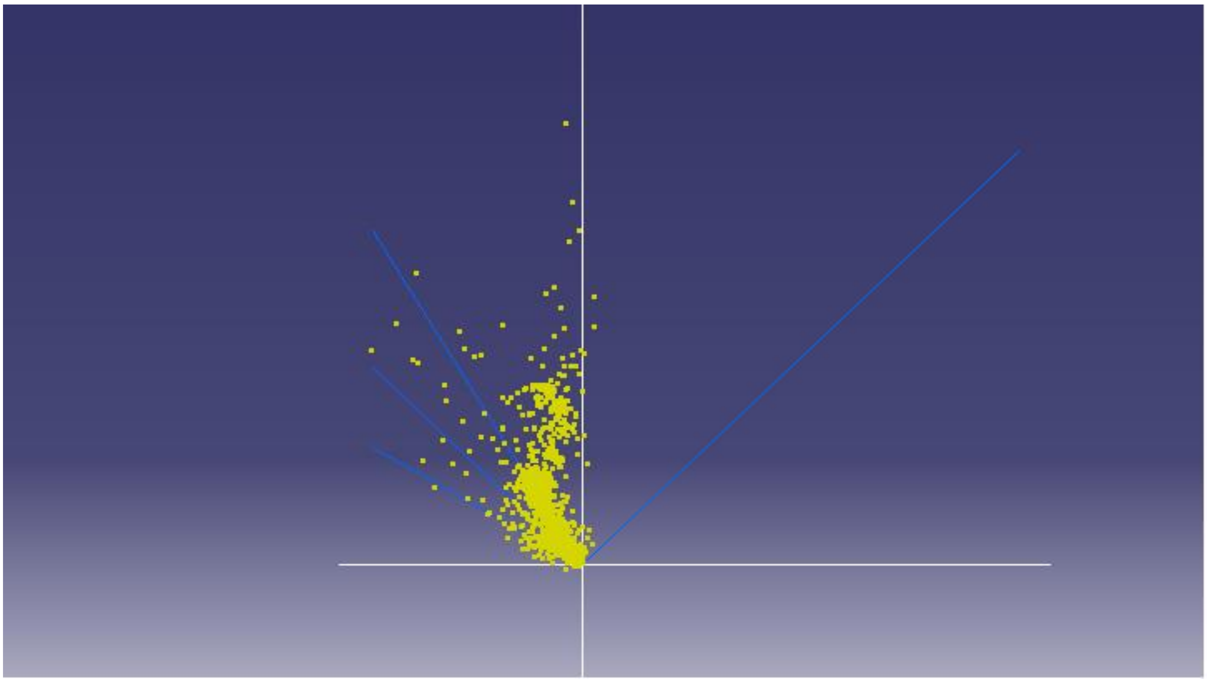

Figure 15: Fld shows safe of component yellow color is all over

- Trial 3(Component thickness 2.5 mm and BHF 15 Ton)

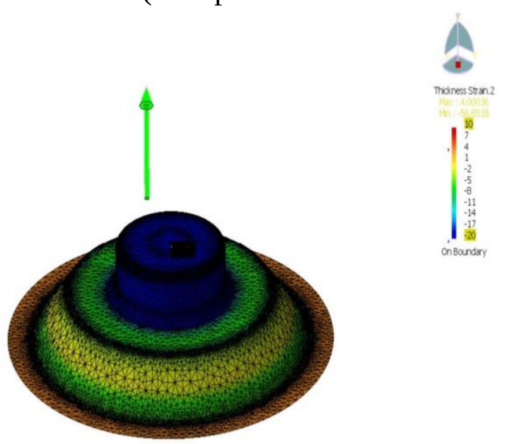

Figure 16: Formed component

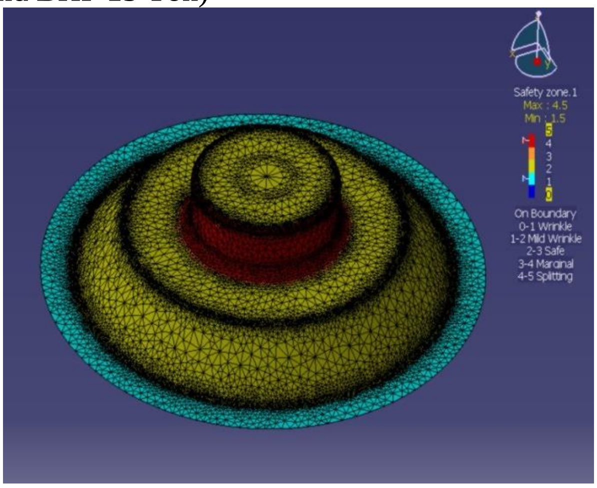

Figure 17: Component test Wrinkles was Formed at corner of component

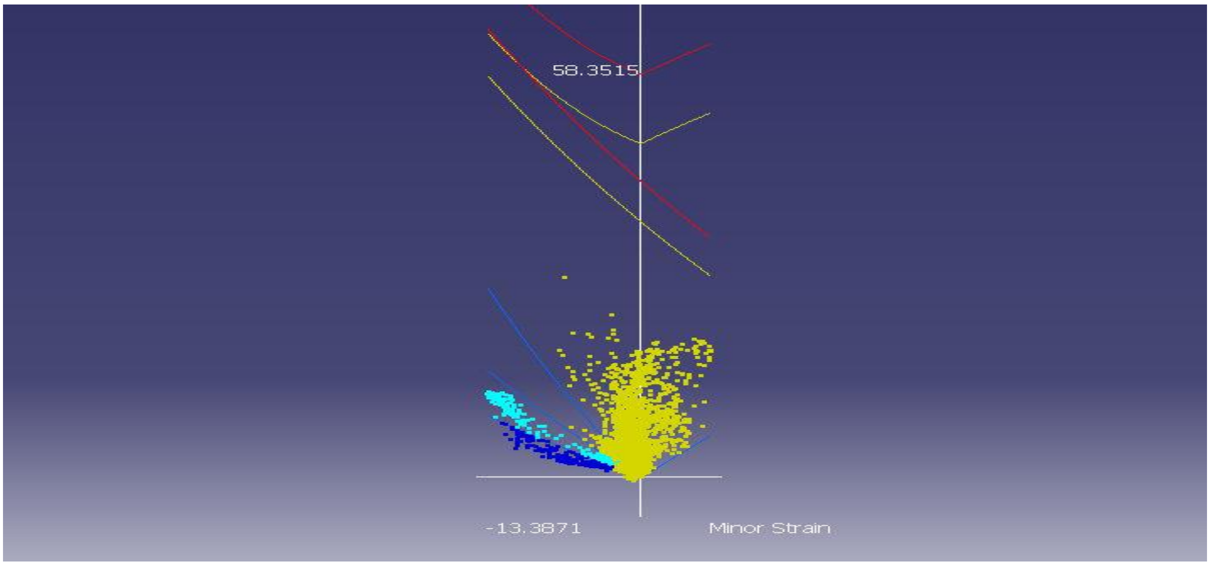

Figure 18: Fld shows wrinkling at 15 BHF

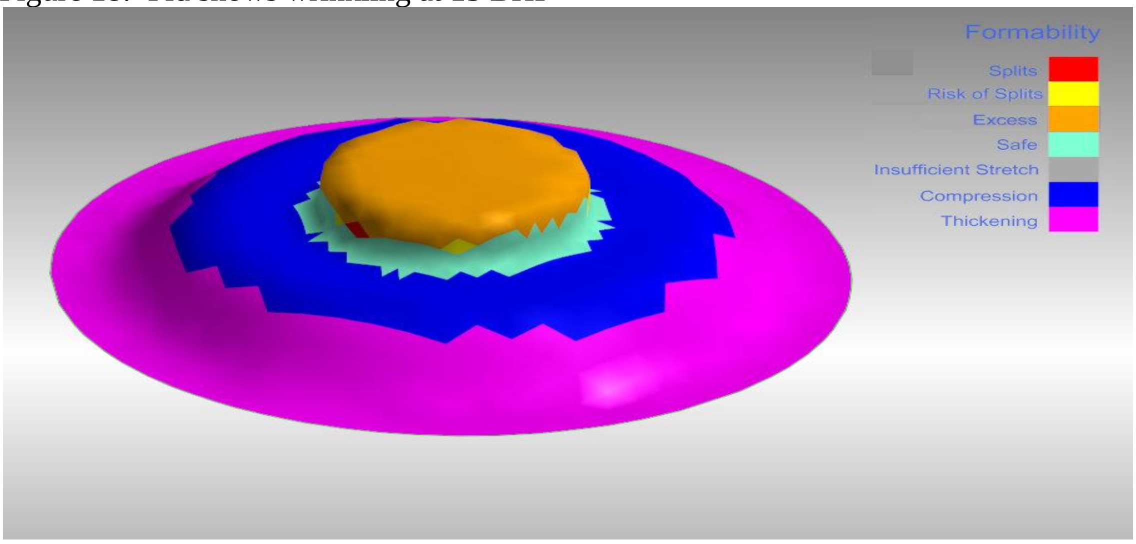

Figure 19: BHF 15 Ton shows wrinkling of component

VI. Result and Discussion

Table.4 -Result

Description for Specs (Material- Aluminum)	**Values for Original Part or Modified part (%Strain) By Micrometer**	**Values for Original Part or Modified part (%Strain) By Hyper form Analysis**	**Remarks for Software Analysis**
1) **Thickness 2.00mm (BHF 20 TON)**	32.2%	32%	For 2mm blank splitting is observed on component
2) **Thickness 2.5mm (BHF 10 TON)**	16%	16%	2.5mm blank with reduced BHF makes the component formable
3) **Thickness 2.5mm (BHF 15 TON)**	19.8%	20%	For 2.5mm blank with increased BHF, tendency of splitting increases.

Effect of the Blank holding force on the wrinkling of cup Flange and splitting of component, To research the effect of the blank holder force on wrinkling of cup flange, this study was carried out with some blank holder force values as 10, 15, 20 KN while other parameters have constant values. The results indicated that when blank holder force is low, the wrinkling is possible to occurs on the flange of cup, with 15 KN, the splitting appears, with the values of20 KN the effect of wrinkles and splitting are reduced and the blank holder force equal to 10 KN the wrinkling on flange of product does not occur. The result shows that the blank holder force plays as important role in cup deep drawing for affecting the wrinkling of flange of the cup, and splitting of the cup.

VII. Future 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.

VIII. 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 finalize.

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