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Design and Analysis of Draw Bead Profile in Sheet Metal Forming Of Reinf-Rr End Upr-Lh/Rh for Safe Thinning

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Abstract: *The quality of component in sheet metal forming is ensured by the material flow into the die cavity. Draw beads are used in sheet metal forming to restrain the sheet from flowing freely into die cavity. By the placement of draw bead and using forming parameters such as blank-holding force and coefficient of friction, the wrinkling, and thinning defects can be reduced. In this project, finite element method is used to analyze the strain and thickness variations during the REINF-RR END UPR-LH/RH forming process by improving the design of a draw bead. Draw bead is designed in such a way that it will produce the part with thickness less than 20% i.e. the desired value. The simulation result is validated with actual component. Special software is available in the market for the simulation of sheet metal parts so that errors and problems occur in the blank during the forming process can be detected. In this case, HYPERFORM software is used for the simulation of the component which avoids manufacturing the tool for the tryout.*
Keywords - *Draw bead, Finite element Method, HYPERFORM, Sheet metal forming, Simulation, Thinning.*

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1. Introduction

The sheet metal forming is the important manufacturing industry as it manufactures chip less products from automobile components to home appliances with process flexibility at possible cost. The quality of sheet metal component depends on the rate of flow of blank into the die cavity. By controlling the material flow rate, we can prevent the defects such as wrinkling and thinning. To control the material flow and to avoid these defects, draw bead is added to die surface or binder surface having its corresponding recess to binder surface or die surface as shown in Fig. 1.

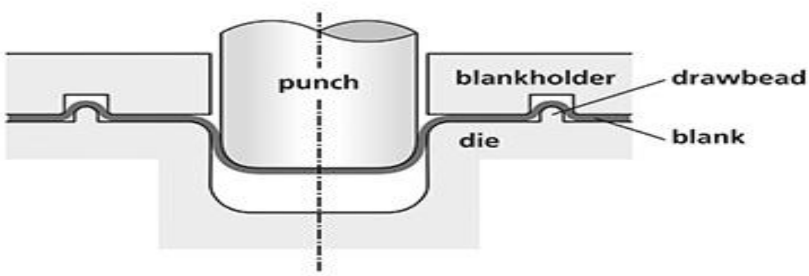


Figure 1: Position of draw bead

The restraining force is provided by the blank holder or draw bead to control the material flow rate and the force is created by friction between the blank & tooling. The sheet metal is subjected to bending and unbending around the draw bead after the die closure. To produce an optimal part with the minimum use of material, the position, height & strength of draw bead can be modified.

Simulation is very important in sheet metal forming operation. It is done in the computer by using simulation software such as HYPERFORM to detect errors and problem occurs in part at an initial phase of the process. It is not required to manufacture tool practically to run the test. Defects like thinning and wrinkling can be calculated in simulation software using the finite element method.

This paper presents the design without draw bead and with circular and step bead shape and its analysis to achieve the minimum percentage of thinning and wrinkling of the REINF-RR END UPR-LH/RH by using finite element method (FEM) with simulation software as HYPERFORM.

II. LITERATURE REVIEW

Murali G et al. [1] focused on the finite element simulation techniques which optimize the location of rectangular and circular draw beads and analyze the strain and thickness variations during the cup drawing process using DYNAFORM simulation software.

M. Samuel [2] studied the behavior of metal flow which will pass through the two shapes of draw beads i.e., single circular and single square female. He conducted the theoretical analysis of bending–unbending deformation with material movement under plane strain. The finite element method was practiced to conclude the stress-strain distribution and restraining forces of the strip. The results obtained by computer simulation were compared with experimental results.

Gasper Gantar et al. [3] focused on the issues related to sheet metal forming such as determination of optimal product shape and optimal initial blank geometry, prediction of fracture, prediction of final sheet thickness, prediction of wrinkling, prediction of loads acting on the active tool surfaces, prediction of spring back and residual stresses in the product. The finite element method using numerical simulation was used to develop the process for the manufacture of defected less part. He used industrial examples for the research. The results of the numerical simulations were compared to the samples from the production process.

Chandra Pal Singh et al. [4] studied the deep drawing process parameters like as blank-holder pressure, punch radius, and die radius, material properties, and coefficient of friction to manufacture the part with a minimum defect.

A. V. Desai et al. [5] optimized the draw bead location and thickness and strain variations were analyzed using finite element method for the panel header drawing process. The draw bead was added to the blank holder to reduce the thinning effect of blank caused due to the forming process.

M. S. Kulkarni et al. [6] studied various criteria such as FEM, numerical analysis, forming limit stress diagram, material optimization, press forming analysis, for the forming process of sheet metal component.

A. P. Petkar et al. [7] used finite element method to replace the trial and error method for obtaining the desired component. Optimization was carried out by using the design of experiments to find out various parameters which affect the quality of sheet metal component.

III. METHODOLOGY

The thinning and wrinkling of REINF-RR END UPR-LH/RH is reduced by the use of FEM simulations. CAD model and specification of REINF-RR END UPR-LH/RH is required for FEM simulation. The CAD modeling of REINF-RR END UPR-LH/RH is done, then from the theoretical calculations the required number of draws and press tonnages are calculated. Further the forming tools are modeled in CATIA V5R25 and this collection of data is used for virtual simulation experimentation. The complete methodology of project is shown in Fig. 2.

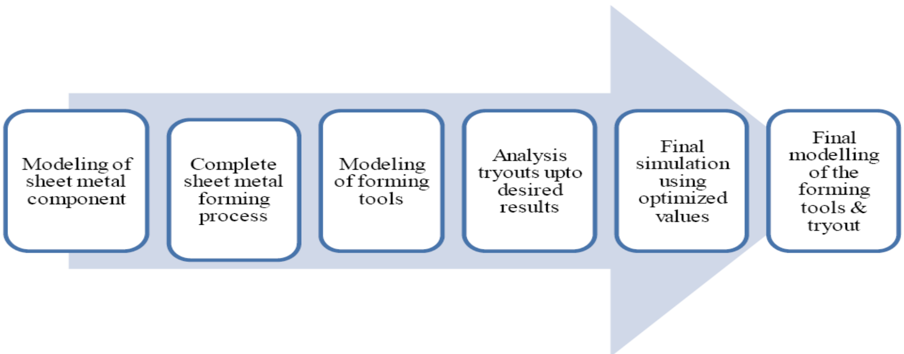


Figure 2: Methodology of project

3.1 Modeling of component

Modeling of REINF-RR END UPR-LH/RH was done in CATIA V5R25 as shown in Fig. 3 as per component specification and IGS provided by R&D department of the industry. Fig.3 shows the isometric view of REINF-RR END UPR-LH/RH.

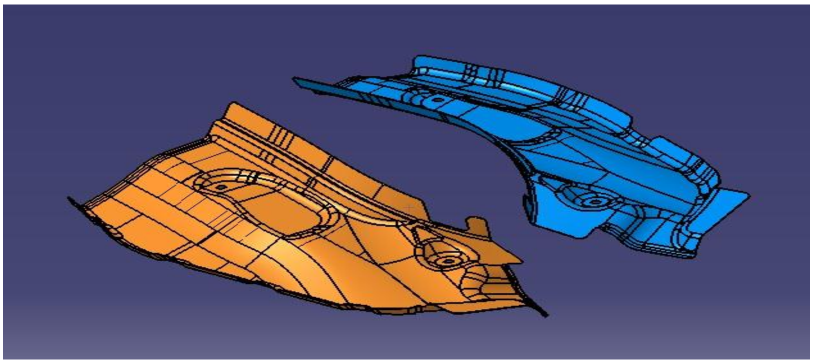


Figure 3: CAD model of REINF-RR END UPR-LH/RH

3.2 Specification of component

1) Material – IFHS350
2) Yield strength (YS) – 220 Mpa
3) Ultimate tensile strength (UTS) – 340 Mpa
4) Thickness – 0.65 mm
5) Develop blank – 740 mm × 715 mm

3.3 Complete process to manufacture the part

The complete process to manufacture the REINF-RR END UPR-LH/RH is shown in Fig. 4.

1) Blanking operation - First operation in single stage forming of REINF-RR END UPR-LH/RH.
2) Forming operation – The blank is deformed to required shape by plastic deformation.
3) Trim operation – It consists of cutting unwanted excess material from the periphery of previously formed component.
4) Restrike operation – The radii and form shape of previously formed component is sharpening in detail. Also eliminates spring back effect. Final component is obtained after this process.

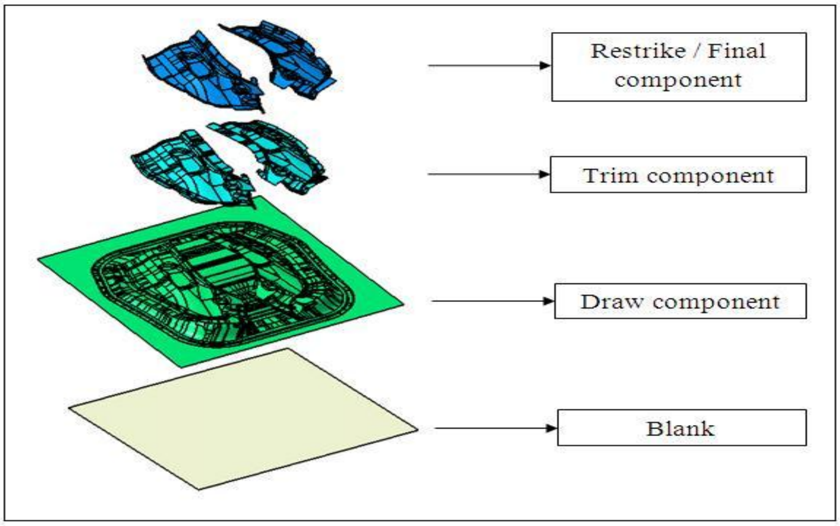


Figure 4: The complete process to manufacture REINF-RR END UPR-LH/RH

3.4 Mathematical Draw calculations

Given data:-

1) Draw perimeter = 1995 mm
2) Draw height (h) = 71 mm
3) Draw constant (K) = 0.6-0.7

3.4.1 Calculation of punch diameter (d) in mm

Punch diameter (d) = Punch perimeter/π

= 1995/π

= 635 mm

3.4.2 Calculation of h/d ratio to find number of draw required

Here, $h/d = 0.111$

$0 < h/d < 0.75$- Simple draw

$0.75 < h/d < 1.5$ - Deep draw

Hence simple draw is required for complete forming of REINF-RR END UPR-LH/RH.

3.4.3 Calculation of blank diameter (D)

$$D = \sqrt{d^2 + 4dh}$$
$$= \sqrt{635^2 + 4\times635\times71}$$
$$= 764 \text{ mm}$$

3.4.4 Calculation of draw force (F)

$$F = \pi d t \sigma_y [D / d - K]$$
$$= 3.14 \times 635 \times 0.65 \times 220 \times [764 / 635 - 0.65]$$
$$= 157798 \text{ N}$$
$$= 16 \text{ Ton}$$

3.4.5 Blank holder load (BHL)

BHL = 20% of draw force (F)

= 3.2 Ton

3.4.6 Draw Tonnage (P) = F + BHL

= 16+ 3.2

= 19.2 Ton

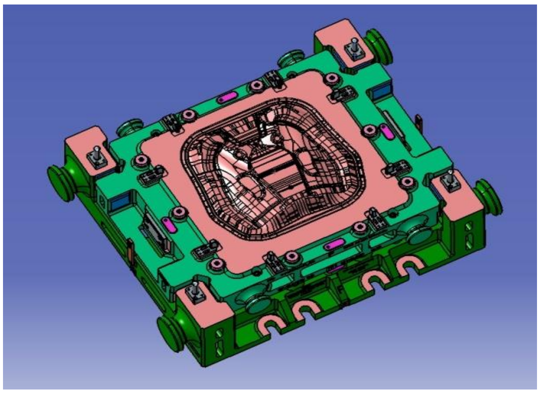
Considering Factor of safety 25% then,

Draw Tonnage = 1.25 X 19.2

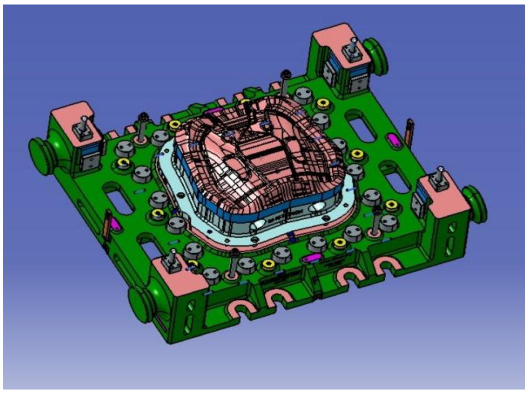
= 24 Ton

3.5 Modeling of forming tool

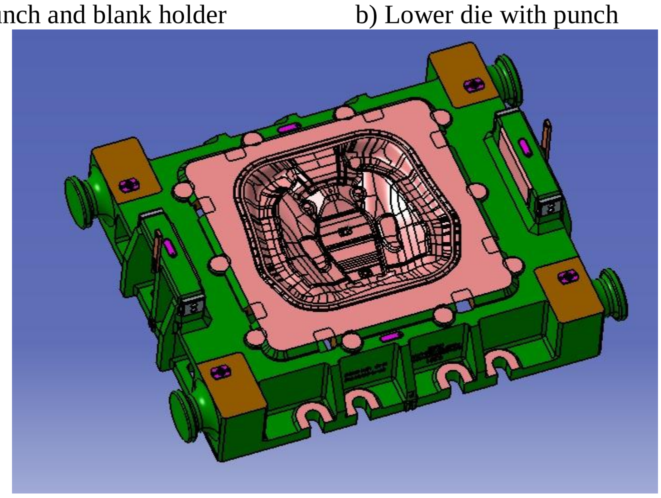
The modeling of forming tool of REINF-RR END UPR-LH/RH is designed as per above process in CATIA-V5 software. The single stage forming tool is as shown in Fig.5.



a) Lower die with punch and blank holder



b) Lower die with punch



c) Upper die

Figure 5: CAD model of forming tool

3.6 Simulation of drawing process

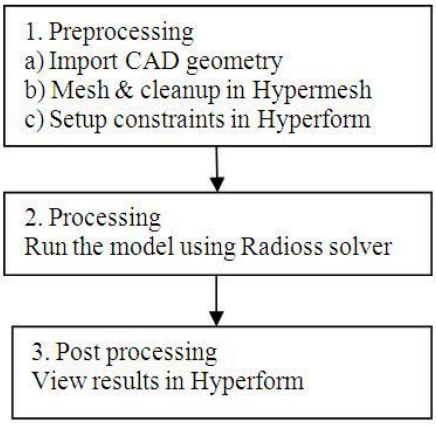


Figure 6: Steps in the simulation process

The steps in the simulation are as shown in Fig.6. Simulation of drawing operation is carried out in HyperForm software using the incremental Radioss platform. The values of press tonnage, blank holder force, and coefficient of friction were calculated which are used to simulate the process. The coefficient of friction was considered as 0.125. The velocity of punch was considered as 5m/s in downward z-direction with stroke distance of 85mm. Initially the blank holder force was set as 24 tons to the negative z-direction.

The component to be formed is transferred to IGES format for the simulation in HyperForm. The mesh was created for upper steel (Die) and blank which gives mesh of blank holder and lower steel (punch) using automatic tool build option. The setup of forming tool is as shown in Fig.7. Several iterations are carried out to achieve the final component with less than 20% thinning with variable draw bead dimensions and variable blank holding force.

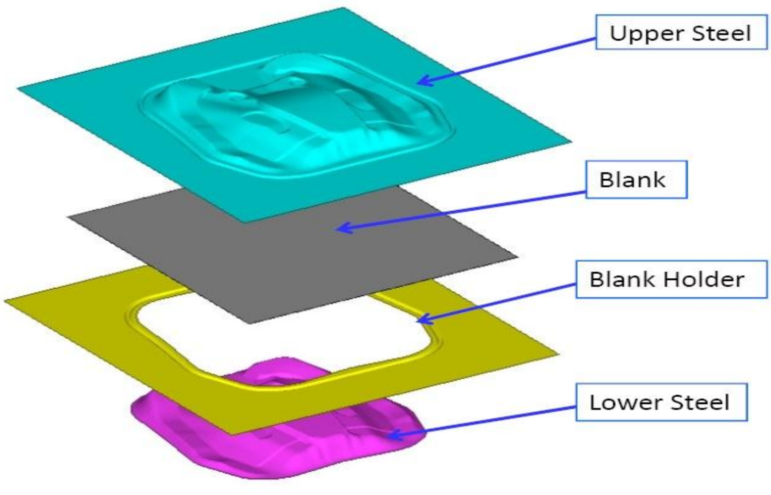


Figure 7: Forming tool set up

3.7 Numerical simulation

The numbers of iterations were performed in Altair's HyperForm software to achieve final component with less than 20 % thinning.

3.7.1 Die design without bead

Initially, the die was designed without bead. The simulation of this die was done in HyperForm software with the incremental Radioss platform. The blank holding force was set as 28 Ton. Fig. 8 shows the die surface section without draw bead.

Figure 8: Section without draw bead

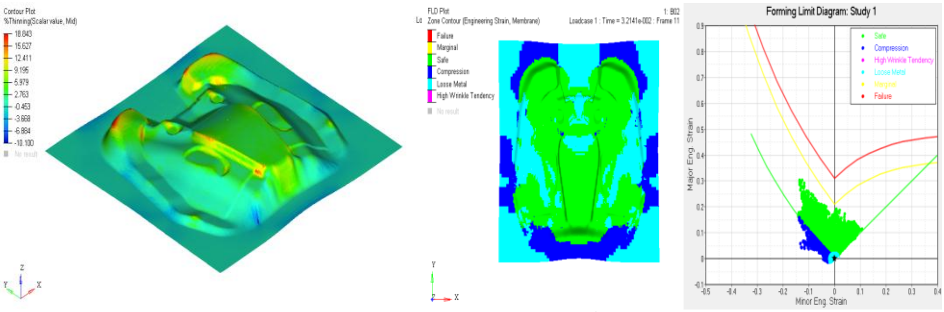


Figure 9: Simulation result of 1st iteration

Fig. 9 shows the result of simulation without a draw bead. It shows safe thinning of 18.843% but forming limit diagram (FLD) shows wrinkle on the part. As the result shows wrinkle in part, we have to go for next iteration.

In third iterations, BHL was set as 60 Ton and no bead is designed for the die.

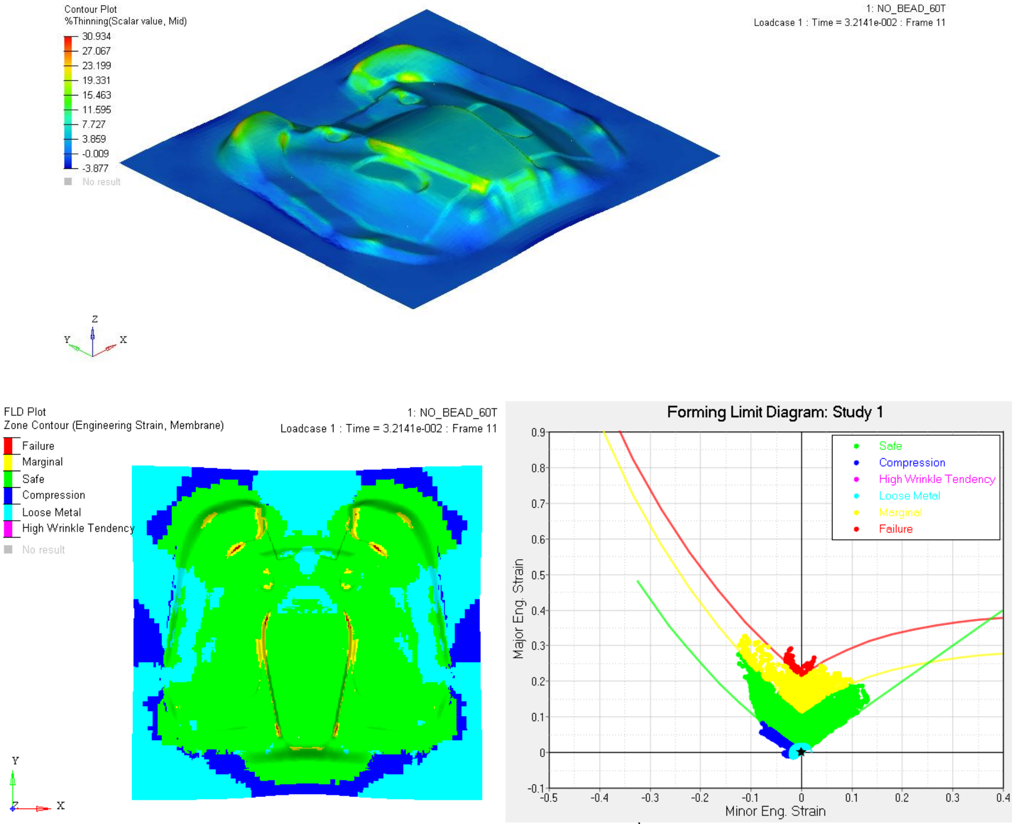


Figure 10: Simulation result of 3rd iteration

Fig. 10 shows the simulation result of 3rd iteration. In this case, thinning occurs is 30.934% which is greater than the desired value. Also FLD shows wrinkle and failure of part. The quality of sheet metal component is ensured by the flow of material into the die cavity. Draw bead helps to flow the blank freely into die cavity. Hence to avoid the wrinkle, we add step bead in next iteration.

3.7.2 Die design with step bead

In this iteration, step bead was added to the die profile with a corresponding recess in the blank holder. Fig. 11 shows die surface section with step bead. The height of bead was considered as 5mm with entry and exit radius as 5mm. The blank holding force was considered as 28 Ton.

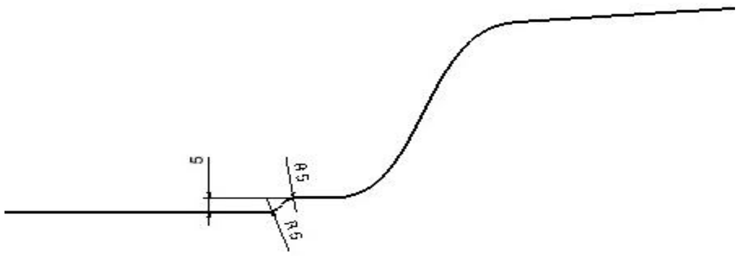


Figure 11: Section with step bead

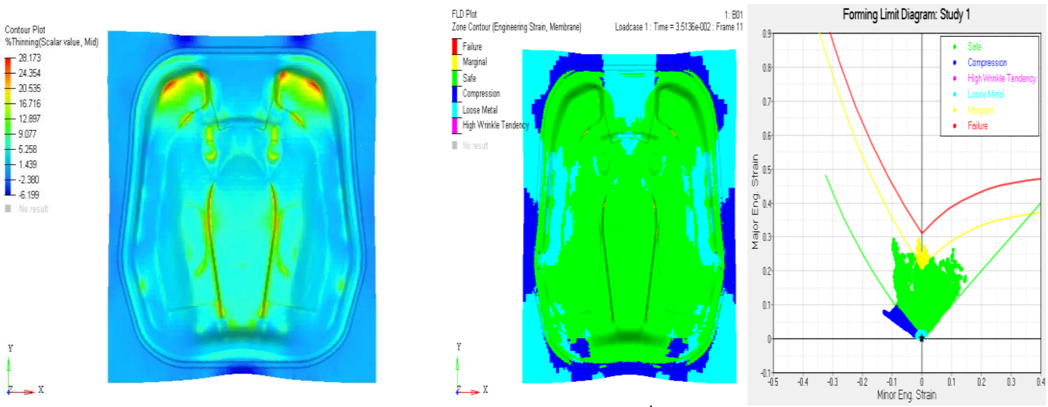
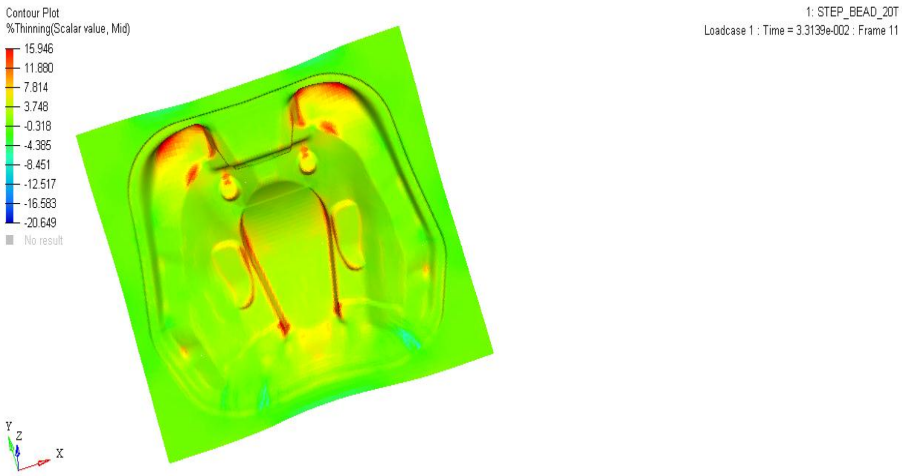


Figure 12: Simulation result of 4th iteration

Fig. 12 shows the result of simulation with step bead. In this case, maximum thinning occurred is 28.173% which is more than desired value i.e. more than 20%. Forming limit diagram (FLD) shows wrinkle on the component. To reduce thinning up to 20%, more iteration is required.

In next iteration, step bead with same dimensions is considered, but BHL is considered as 20 Ton. The simulation result of this load is shown in Fig. 13.



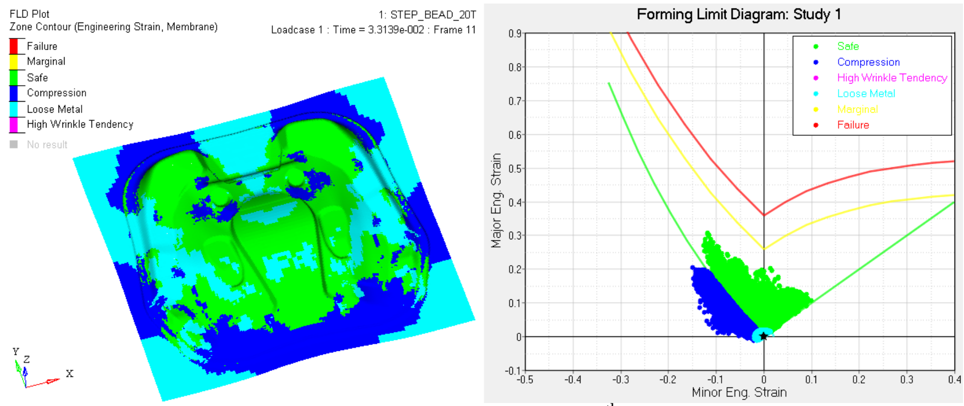


Figure 13: Simulation result of 5th iteration

Fig. 13 shows thinning of blank within the desired value but FLD shows presence of wrinkle on the form component. So we have to proceed for next iteration.
In next iteration, BHL was considered as 60 Ton with same dimensions of step bead profile.

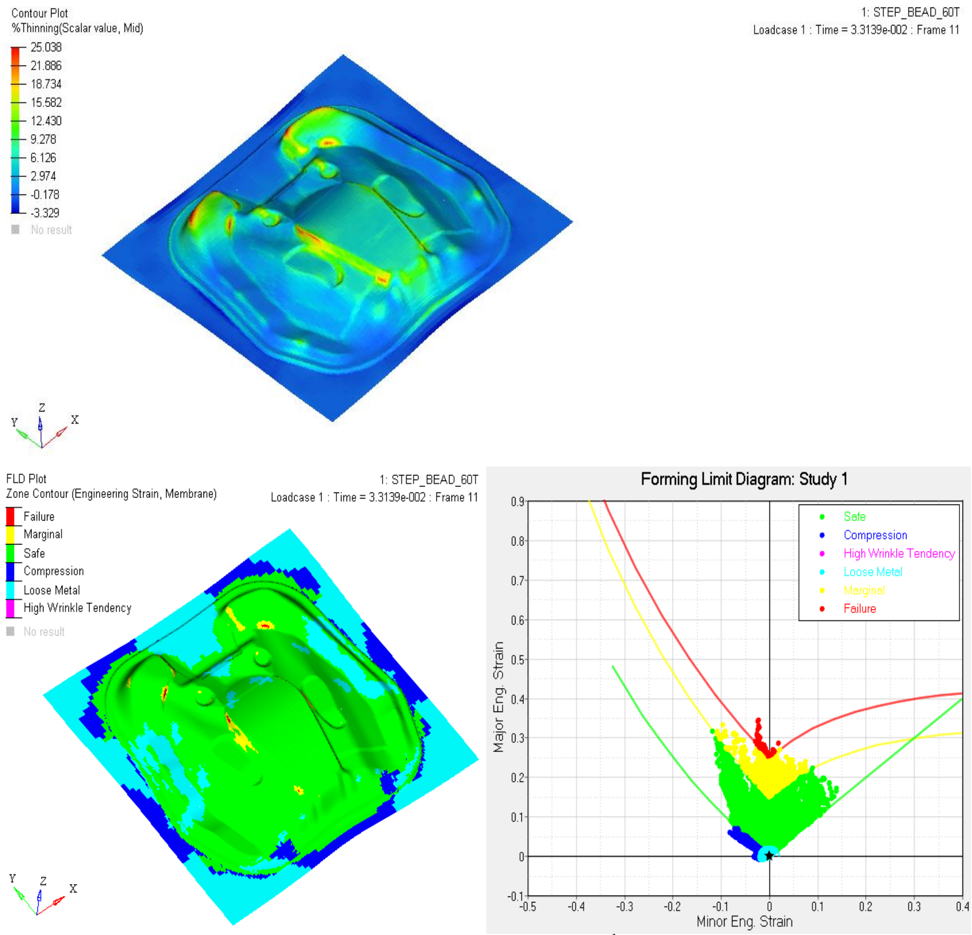


Figure 14: Simulation result of 6th iteration

Fig. 14 shows thinning of blank is above safe value. From FLD, we can conclude that there is presence of wrinkle on part and also in some area part is in failure. So we have to take more iteration until the safe thinning will occur and there should be no tendency of wrinkle and any failure of part. Here we have considered only six iterations.

3.7.3 Die design with circular bead

After step bead, the circular bead was added to the die profile. Fig. 15 shows section of die surface with circular bead where R2 as entry side radius, R3 as exit side radius and R1 as bead radius which corresponds to the height of bead. The standard dimensions of the bead are R2 and R3 as 4 mm and R1 as 6 mm. With variations in these dimensions of circular draw bead, numbers of iterations were performed. After so many iterations, with a change in dimensions of the circular bead, finally R2 and R3 were considered as 5mm and R1 as 6mm. The blank-holding force was considered as 28 tons. The simulation was carried out with these details.

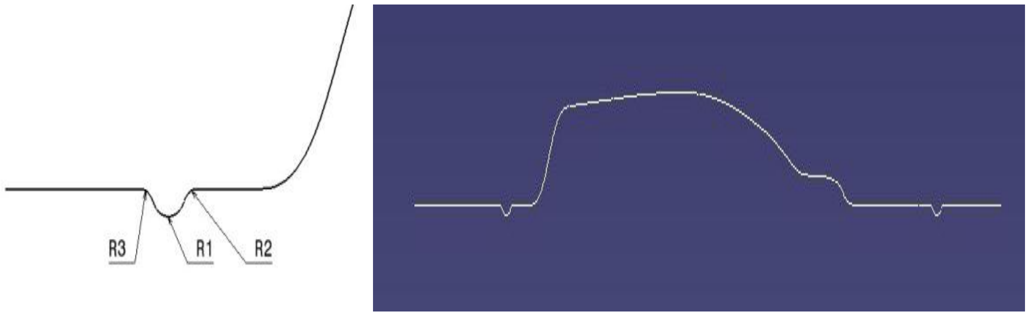


Figure 15: Section with circular bead

IV. RESULT AND DISCUSSION

After multiple trials of simulation with different dimensions of draw bead profile of REINF-RR END UPR-LH/RH, the final result is obtained with circular draw bead with dimensions mentioned as above.

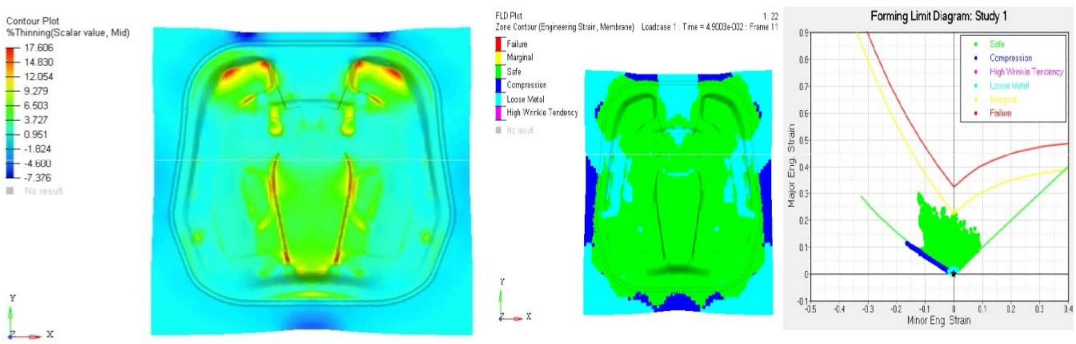


Figure 16: Result of die with circular bead

Fig. 16 shows the result of simulation with circular draw bead. It shows maximum thinning of 17.606% in the component which is less than the desired value of 20% and FLD diagram shows no tendency of wrinkling. Final part is manufactured after the simulation process is finalized.

V. EXPERIMENTAL VALIDATION

Fig. 17 shows final draw component. The thickness is measured at 12 different locations and % thinning by experimental and simulation process are shown in Table 1.

Figure 17: Final component

Table 1: Comparison of thickness distribution

Sr. No.	Experimental (%)	Simulation (%)
1	15.38	17.606
2	16.10	17.606
3	4.61	3.72
4	6.15	6.503
5	9.23	6.503
6	7.69	9.279
7	9.23	9.279
8	10.76	9.279
9	4.61	0.951
10	10.76	6.503
11	6.15	6.503
12	13.84	12.054

As maximum thinning in both process are same, by experiment process it is varied between 13.84 % - 16.10 % and by simulation process thinning is varied between 12.054 % - 17.606 %. We can say that the simulation result is in good agreement with experimental result (± 4% error).

VI. CONCLUSION

Step and circular draw beads have been used to analyze the thickness and strain distribution pattern in the forming of REINF-RR END UPR-LH/RH using finite element analysis. For this, CATIA V5R25 has been used to design the model and HyperForm have been used for the simulation. FEA results are in good agreement with experimental result. Following remarks were drawn based on study.

- Draw bead is necessary to avoid wrinkling and thinning of component.
- Circular draw beads are preferred over step bead because thinning is lesser with the circular bead as compared to step bead.
- Final design of die was made after numbers of iterations perform in Altair's HyperForm by optimizing profile of bead and blank holding force.
- Due to simulation, cost and time required to manufacture the tool for tryout is save.
- Simulation results are in good agreement with experimental result (± 4% error)
- Safe thinning of component is achieved i.e.17.606 % which is less than desired value.

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REFERENCES

[1]. A. Murali G., B. Gopal M. and C. Rajadurai A, "Analysis of Influence of Draw Bead Location and Profile in Hemispherical Cup Forming", International Journal of Engineering and Technology, vol. 2, no. 4, pp. 356-360, 2010.
[2]. M. Samuel, "Influence of drawbead geometry on sheet metal forming", Journal of Materials Processing Technology, vol. 122, no. 1, pp. 94-103, 2002.
[3]. G. Gantar, T. Pepelnjak and K. Kuzman, "Optimization of sheet metal forming processes by the use of numerical simulations", Journal of Materials Processing Technology, vol. 130-131, pp. 54-59, 2002.
[4]. C. Singh and G. Agnihotri, "Study of deep drawing process parameters: A review", International Journal of Scientific and Research Publications, vol. 5, no. 2, pp. 1-15, 2015.
[5]. A. Desai and P. Deshmukh, "Influence of Draw Bead in Panel Header Forming Process Simulation", International Journal of Trend in Research and Development, vol. 4, no. 5, pp. 258-260, 2017.
[6]. M. Kulkarni and S. Gajjal, "Review of Sheet Metal Forming Analysis", SSRG International Journal of Mechanical Engineering, vol. 2, no. 1, pp. 1-4, 2015.
[7]. A. Petkar and D. Zoman, "Optimization of Forming Process Parameters for Appropriate Distribution of Wall Thickness in Sheet Metal Component", International Journal for Research in Applied Science & Engineering Technology, vol. 4, no. 7, pp. 125-134, 2016.

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