International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 7, July - 2014

Modelling and Failure Analysis In Sheet Metal Forming Process using Cae

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***Abstract*— Forming defects have an important impact on the forming quality of metal parts. In this paper complex part B-Pillar is considered for the forming process. Based on CAE (Computer Aided Engineering) the process of modelling and failure analysis in forming was simulated. The creation of finite element model, the choice of material model, the establishment of boundary conditions and the treatment of contact friction and so on were carried out. With the changes of technical parameters, modelling and failure analysis in forming process is made further understanding, the potential forming defects may be predicted, the proper technical parameters are chosen to restrain or eliminate forming defects, and consequently the forming quality of the parts and efficiency of manufacture are improved. These results provide significant guidance to the manufacturing of sheet metal parts in forming process.**

Keywords*— Forming defects, CAE, technical parameters, Finite element, Simulation.

I. INTRODUCTION

Metal forming is a very important manufacturing operation. It enjoys industrial importance among various production operations due to its advantages such as cost effectiveness, enhanced mechanical properties, flexible operations, higher productivity, considerable material saving.

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 like Hyperform, Autoform, Dform etc. That would predict the trial results without actually conducting the same. The simulation offered by the software during the process of Deep Drawing lends important insights into the modifications needed in the die and/or the component to affect a simplified and productive die. In this study, a B-Pillar car part of material CRDQ steel and blank thick of 1 mm is simulated by using Altair's HyperForm radioss to study the effect of these parameters on failure modes and thickness distribution.

II. SOFTWARE DESCRIPTION

Altair, Hyperform is used for simulation in this work.

A finite element pre and post processors (Hyperform) is a graphic based software package primarily designed to aid in the development of Finite Element Model (Pre processing) and to aid the display and interpretation of analysis results (Post processing). Altair's HyperForm is a mechanical Computer Aided Engineering software package, utilizing integrated automatic technologies. CAE has been an integral part of forming process design to analyze and optimize the metal flow and conduct die stress analyses before trial runs. It enables design engineers to build and modify solid models of components and predicts their behavior through design optimization. In addition preprocessing application helps the analyst modify the model if the result shows that changes and subsequent reanalysis are required. Hyperform solution helped re-design the tooling for the part in a very short time of 20 days as against a manual exercise which could have taken 2-3 months involving a lot of physical trials. The world class processes led to improvement of quality of their manufacturing process and tool design and product delivery quality.

III. RESULTS AND DISCUSSIONS OF B-PILLER

As we discussed in earlier section about the sheet metal forming computer simulation is used in this section. There are four iterations are discussed below, during sheet metal forming, it is necessary to control the rate of metal flow into the die cavity. The control of metal flow can be achieved through the blank holder, flange shape, drawbead, or a combination.

Drawbeads are used to control the flow of sheet metal into the die cavity during deep draw forming of large panels. They prevent wrinkling in formed panels, reduce the blankholder force, and minimize the blank size needed to make a part. Drawbead restraining force and failure location in the formed sheets are usually evaluated by using drawbead simulation tooling. Some of the drawbead process parameters used are listed below. These process parameters are kept constant and other parameters like velocity, travel distance, blank holding force are varied.

Table 1: Drawbead process parameters.

Drawbead process parameters	Values
Drawbead height	6.25mm
Drawbead radius	6.25mm
Shoulder radius	2mm
Restraining force	55.1N
Necking condition	16.5%
Coefficient of friction	0.125

There are four iterations are conducted to find the best solution for the B-pillar part but only best solution counter plots are shown i.e. Iteration No.4.

ITERATION NO.4

Input process parameters are,

Travelling tool is DIE

Travel 1 is -21mm

Travel 2 is -76.5mm

Velocity 1 is 5000mm/s,

Velocity 2 is 10,000mm/s,

Binder force applied is 10,000N

Draw beads = yes

With the use of above parameters value, we are getting good quality product so these values are considered for manufacturing of B-Pillar part.

A. Deformation of material:

Displacement counter plot is shown in the figure, red region shows more displacement and blue region shows less displacement.

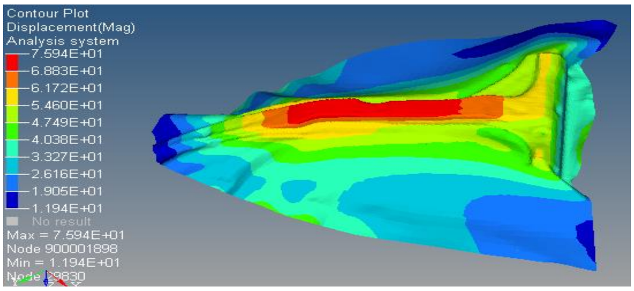

Fig. 1 Deformation of material

Observation: Maximum Deformation recorded 75.94mm of the component

The maximum deformation is 75.94mm it is total punch travel distance (sum of depth and distance between Punch and Die) at Node number 900001898. The minimum displacement is 11.94 at Node number 29830.

B. Percentage of Thinning:

Maximum percentage of thinning is 26.82% at element number 900254915 and minimum percentage of thinning is -28.33% at element number 900244276.

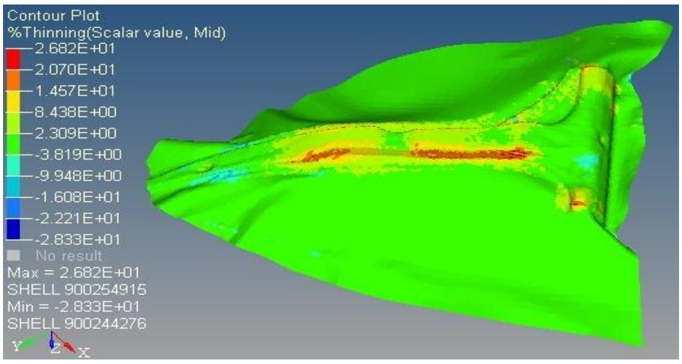

Fig. 2 Percentage of thinning

Observation: Maximum thinning recorded 26.8% of the thickness of the component (Acceptable part quality)

Metal flow in the volume elements at the periphery of the blank is extensive and inwards as increases in metal thickness caused by severe circumferential compression, this increase in the wall thickness at the open end of the wall. The changes in percentage of thickness are shown in fig. 2. The simulation result shows that maximum percentage of thinning is 26.8% (red zone), it is normal, so this process parameter values are acceptable.

C. FLD Plot:

Forming limit diagram Fig.3 represents that blue zone having maximum compression resulted in increased thickness , red zone having Failure zone results in cracks, parret zone having safe results no failures and same as blank thickness. In fig.3 no failure zone is observed due normal percentage of thinning so these process parameter values are accepted.

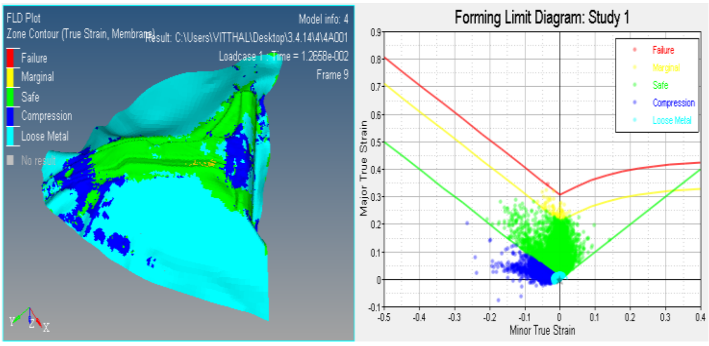

Fig.3 FLD Plot

Observation: No failures are observed: *part is accepted*

D. The final part of B-Pillar:

The final part of B-Pillar is shown in fig.4; it is a trimmed part of extra surfaces surrounded by part or flange.

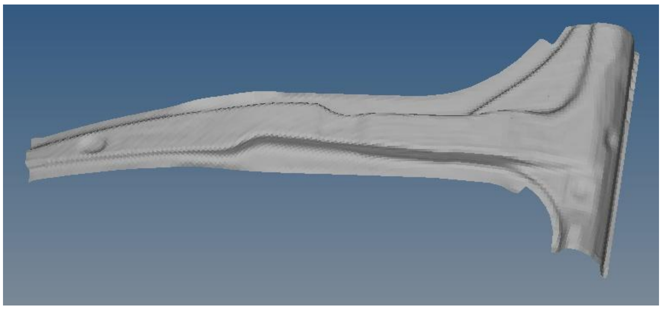

Fig.4 Final part after trimming the extra surface.

E. The final part with main geometry:

Formed final B-Pillar part is matched with CAD geometry. In the fig. 5 we can see formed part is totally matching with CAD geometry.

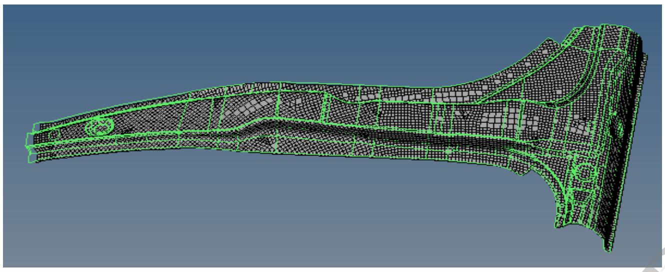

Fig. 5 Final part matched with main geometry.

F. Comparison of four iterations process parameters:

Input and output process parameters four iterations are listed in table 2. The change of output parameters like deformation, percentage of thinning and FLD plots are shown in table. In first three iterations, we observed failures in FLD plot so these input parameters are rejected. In forth iteration percentage of thinning is minimum and did not observe any failures in FLD plot so these process parameters are acceptable for manufacturing.

Table 2: Process parameters used for different iterations

		ITERATION 1	ITERATION 2	ITERATION 3	ITERATION 4
INPUT PARAMETERS	TRAVEL 1	0	0	-20	-21
	TRAVEL 2	-76	-76.3	-76	-76.5
	VELOCITY 1	0	0	2000	5000
	VELOCITY 2	5000	10000	5000	10000
	BINDER FORCE	10000	10000	10000	10000
	DRAWBEADS	YES	YES	YES	YES
OUTPUT PARAMETERS	MAX. DEFORMATION	76.2	76.2	76.1	75.9
	MAX. % OF THINNING	52.9	45.6	57.2	26.8
		Failures Are Observed	Failures Are Observed	Failures Are Observed	No Failures Are Observed
REMARK		PART IS REJECTED	PART IS REJECTED	PART IS REJECTED	PART IS ACCEPTED

In first two iterations only one depth of draw is used and the results obtained are failures. In third iteration two depth of draw are used, still for these input parameters failures are obtain as observed in FLD plot. Iteration 4 input parameters are acceptable, no failures are obtain and thinning percentage also very minimum ie. 26.8%, upto 28% for this part is acceptable.

IV. CONCLUSIONS

CAE software support (HYPERFORM) has offered a feasible solution to the problem at hand. In deep drawing operating condition involving the punch velocity and travel distance are varied and the results analyzed. Displacement, Thinning and Formability are ascertained in this study. Suitable process parameters are recommended for a defect-free component as per fig.1, 2 & 3 and improved the product quality. And also minimizes cycle time and other process parameters in deep drawing process. Using HyperForm 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 finalized.

V. FUTURE SCOPE OF WORK

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.

As the results obtained from HyperForm is in good agreement the study of different Parameters viz. lubrication, strain hardening exponent, strain rate and earing evaluation can be carried out for similar product. Lubricant selection is not there in Altair Hapermesh software so this also effects to forming process.

VI. ACKNOWLEDGEMENT

We thank Mr. S. Krishnamoorthy of Rheomold, Pune, for the advise we have received from him in the due course of the work and faculty of Mechanical Engg. Dept., Gogte institute of technology, Belgaum for their constant support and inspiration.

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