

Tube Forming using Hydroforming Technology and analyzing the process on Explicit Dynamics

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Abstract—Tube forming being the most unified need for every automotive company, needs to be taken care of throughout the manufacturing process. Various automotive sectors have range of complex geometries of tubes and these geometries are classified by group technology. The THF process enables these sectors to produce tubes that are light in weight, without causing any losses in the material strength after the THF process. This study describes the Analysis of THF process for a simple circular c/s tube which is converted into rectangular tube. The equivalent Von-Mises stress generated is the main factor for THF process in this study. Material of the tube is E34 4012A CS. MISO is the plasticity model used and Explicit Dynamics solver is used on ANSYS.

Keywords- ANSYS, Explicit Dynamics, MISO, THF, Von-Mises stress.

I. INTRODUCTION

Tube hydroforming, THF contrives to be the emerging technique for forming the tube having complex geometry. Hydroforming uses fluid pressure to form the components which has intricate corners and edges that can be damaged easily when formed with other forming processes. The normal forming of tube has stages that undergoes various processes and thus the mechanical as well as chemical properties are likely to get changed in the final product, the strength of the final product thus changes. Tube Hydroforming causes change in the mechanical and chemical properties as well, but to an extent which does not affect the requirements of the final product. It is of utmost need to consider the maximum pressure up to which the tube can behave to be ductile without bursting. THF is a replacement to conventional forming, as it uses the high pressurized fluid to form the blank instead of the solid die as a counter mould that is been used in case of deep drawing.

II. MATERIAL

In current study the Carbon steel, E34 4012A grade is used in Tube Hydroforming process.

TABLE 1
CHEMICAL COMPOSITION OF E34 4012A, CS

	C%	Mn%	S%	P%	Al%	Si%
E34 4012A	0.060	0.631	0.004	0.009	NA	0.236

III. METHODOLOGY

THF based on ANSYS deals with the major problems linked to the conventional method. There are losses which results in the ineffective process plan strategy. The process should be planned in such a way that there are minimal losses and good percentage of profit that grows along with the manufacturing. Analysis and Design Software plays important role when it comes to developing a model and confining a path which it goes through. There are analysis software's which shows the advanced and effective results when it comes to analysis of a process to obtain best possible results depending on the required outputs. Here in the following study, ANSYS software is used. Explicit dynamics is the solver that deals with the problems that relate to dynamic loadings. The THF process has nonlinear conditions which can only be dealt using explicit dynamics. The algorithm through which the effects of process parameters are analyzed:

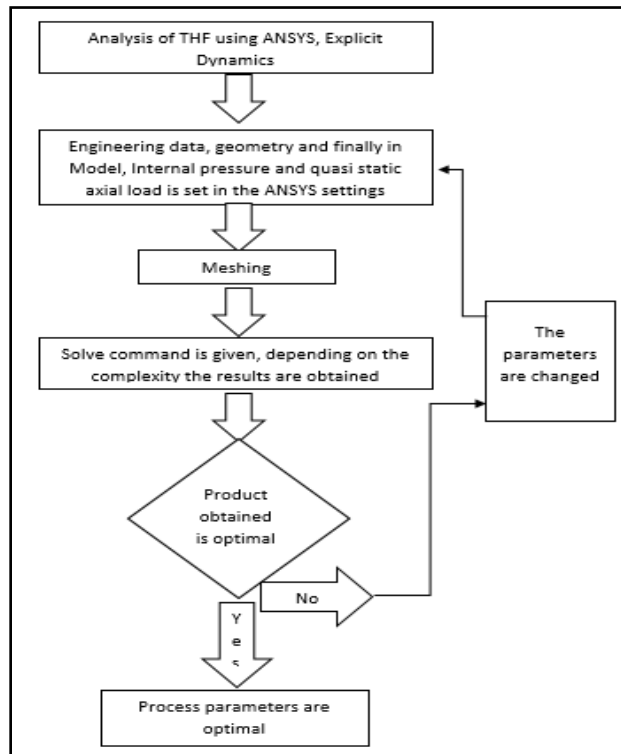


Figure 1. Algorithm followed by ANSYS, Explicit Dynamics

ANSYS 18.2, Explicit Dynamics tools help users meet solution requirements of various complexities based on problem details and user expertise, thus this method undergoes various steps. The very initial step for any Analysis work is the engineering data which can only be obtained when material undergoes certain tests. Depending on the Analysis, ANSYS 18.2: Explicit Dynamics solver which uses MISO (Multilinear Isotropic Hardening) requires only Tensile test so as to obtain the true stress v/s strain graph. The Explicit dynamics solver has a lots of models amongst which some are based on Kinematic hardening whereas some are based on isotropic hardening The basic difference between the isotropic hardening and Kinematic Hardening is as follows:

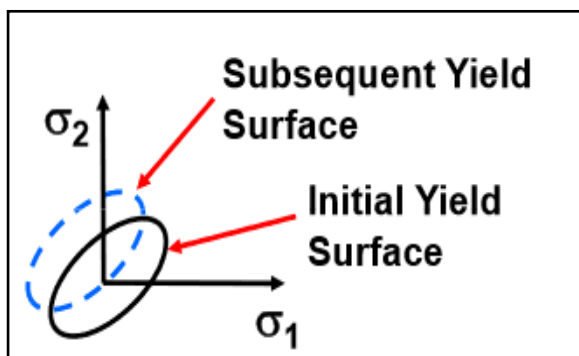


Figure 2. Kinematic Hardening

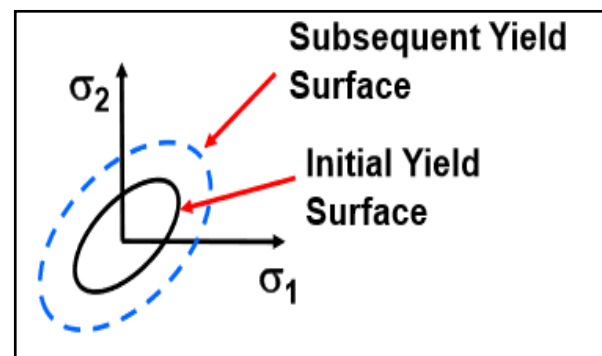


Figure 3. Isotropic Hardening

In Kinematic Hardening the yield surface remains constant in size and translates in the direction of yielding whereas in case of Isotropic Hardening the yield surface expands in all the directions with plastic flow. As there are many nonlinearities in THF and as the yield surface expands in all direction of yielding, therefore MISO is used in the study. The MISO requires various input parameters such as true stress and strain points which should be 10 points starting from the yield point at any given temperature for which the strain is zero. As we give 10 points as input the true stress strain plot can be observed as the input to MISO model.

Plotting of stress strain curve enables observable loading and reverse loading cycles. The isotropic hardening is used for large strains or equivalent loads and not advised to be used in cyclic processes. The isotropic elasticity in MISO requires Poisson's ratio, Young's Modulus and density of the tube material used. The static structural steel is the default material used, E34 4012A is carbon steel and thus it should be added in the Engineering data. For E34 4012A, Poisson's ratio =0.3, Modulus of elasticity=2.1 x 10¹¹Pa, Density =7850kg/m³ is given as data input in isotropic elasticity. The water temperature ranges from 24°C to 28°C. The tensile test results in the load v/s deflection diagram. This load v/s deflection diagram is converted to engineering stress strain curve using the mechanical properties obtained from the load v/s deflection diagram. There are calculations which gives stress strain points, but accurate results were required as the same engineering stress strain points are further converted to true stress strain points. The following can be used to convert the engineering stress strain points to real/true stress strain points.

Up until twice the strain at which yielding occurs:

$$\sigma = \sigma_{eng} \text{ and } \epsilon = \epsilon_{eng}$$

Up until the point at which necking occurs:

$$\sigma = \sigma_{eng} (1 + \epsilon_{eng}) \text{ and } \epsilon = \ln(1 + \epsilon_{eng})$$

Geometry can be imported from SOLIDWORKS, which is assembly of lower die and a tube. The same can also be made in the ANSYS geometry within the software. For the study half sectional assembly is considered to check the parameters. The OD of the tube is 117 mm Thickness is 3.6 mm and length is 200 mm. The c/s of the die is 136.05 mm wide (outer), 21.01 mm height from inside flat surface and 50 mm height from outside flat surface, 20 mm thick and length same as tube.

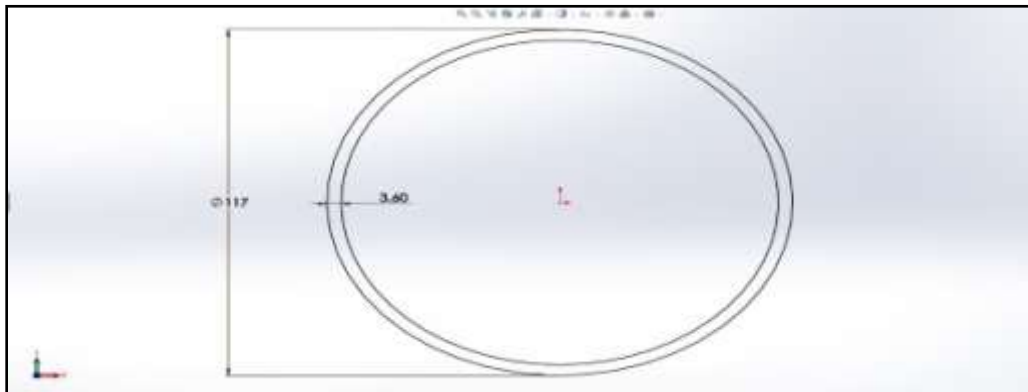


Figure 4. Circular Tube c/s

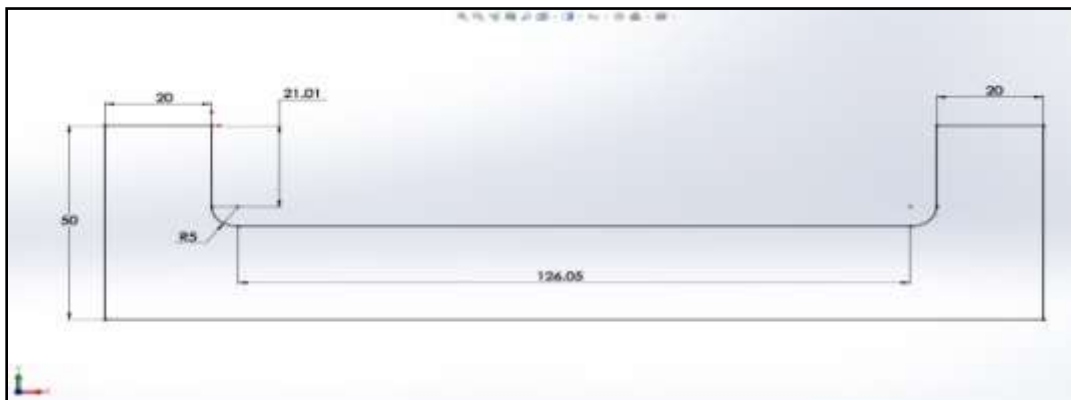


Figure 6. Die c/s

Modelling is the most important step in ANSYS. The contacts are deleted and the die is kept rigid, Tube is made flexible and all the contacts are deleted. The default material for both is structural steel which has been changed to carbon steel for tube and for die structural steel is default material that the software selects. As mesh generation is done, model is discretized into elements depending on the geometry. For this study mesh generation creates coarse mesh. Further Body sizing for the die and Edge sizing for the tube is done which generates good meshing results. In the Body interaction, the friction is kept 0.2. All the analysis settings are done in the modelling stage. The meshing results for the tube on Explicit dynamics model results as follows:

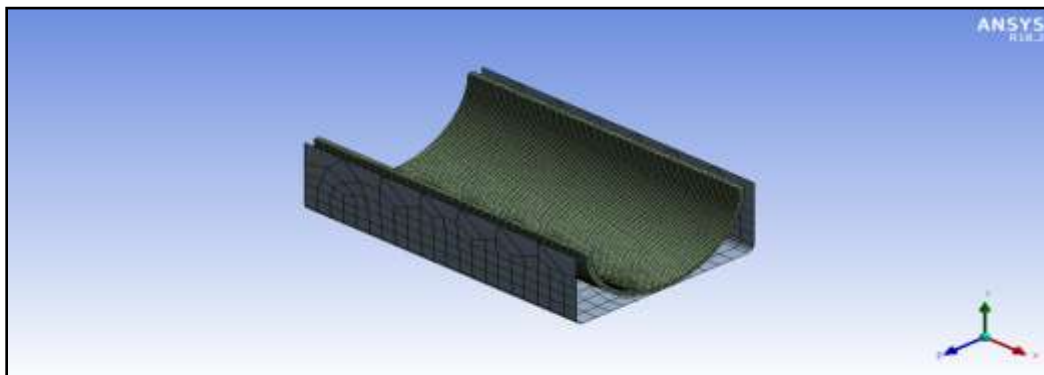


Figure 7. The meshing results for the tube and die on Explicit dynamics model

IV. RESULT AND DISCUSSION

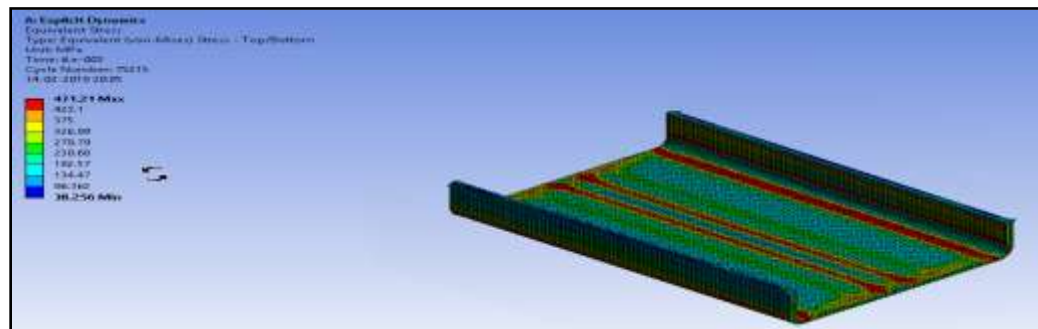


Figure 8. Von-Mises Stress Distribution after hydroforming a circular tube to rectangular

The Von- Mises maximum equivalent stress is 471.21 MPa which is above the yield strength and very much below the ultimate strength of the material.

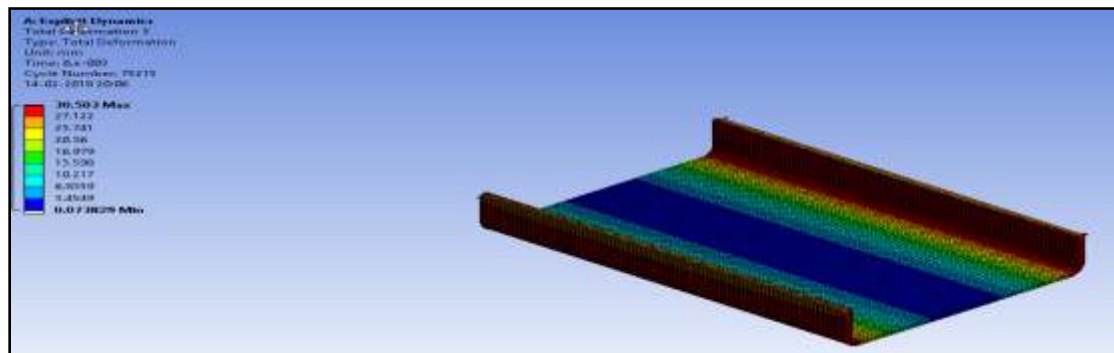


Figure 9. Total Deformation after hydroforming a circular tube to rectangular

The total deformation obtained is 30.503 Maximum.

V. CONCLUSION

In the case study, E34 4012A CS tube was the material which was used for Hydroforming Process. The free Bulging criteria of Tube Hydroforming was Analysed. The Internal Pressure was the Boundary condition. The plunge that holds the tube in between the lower and upper die exhibits the force axially which is very small in this case and thus the force exerted was very small which could only hold the tube and also quasi static, slow and reversible. Therefore, the axial force is neglected in this study. Following important conclusions can be drawn from the results of the case study:

- High Internal Pressure compared to axial Force can cause bursting of the tube.
- As trial and error method gives results that may cause waste up to 'n' processes. Where 'n' tends to the number of iterations until the desirable result is obtained. No. of iterations depends on the technical skills of the operator and the operation head. Thus Material costs is saved by 20%-40% by using ANSYS: Explicit Dynamics.
- There is reduction in time used for every setup that requires at least 15 minutes to settle the machine after removal of waste and to set parameters in the machine. Every 15 minutes that are wasted for such 4 failures in a month reduces 20 products that can be produced more. The calculations done are on an average scale considering from October'17 to Jan'18

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