FINITE ELEMENT ANALYSIS OF COMPONENT DEVELOPED BY TUBE HYDRO FORMING

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ABSTRACT

Hydro-forming technology is one of the most popular techniques for manufacturing of tabular shape component. This technique is mainly used for tube hydro forming [THF] and sheet work [SHF] with the use of high pressure fluid. In the heavily populated countries like India, Indonesia and China, maximum population opt two wheelers for their primary use of transportation. This arise competition between the industries for advance manufacturing and continuity in qualitative product delivery and also with cost and time savings. Hydro forming process emerges rapidly; forming process is very fast that forms raw material in to final product by flow into a die cavity, achieving final component shape. This content of work is task for the process evaluation with the help of modeling and FEA-Simulation of the hydro forming process for the tabular shape component using LS-DYNA software. The analysis is comparative study of the effect of parameters like distribution of stress along the surface of component for validation purpose.

Keywords -Tube Hydro forming, Modeling, Buckling, LS-DYNA

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INTRODUCTION

Hydro forming is a special type of forming process that uses a high pressure hydraulic fluid to press working material into a die at room temperature. Hydro forming technology is able to produce stronger, lighter rigid structures for vehicles. Tube hydro forming [THF] is one of most advance unconventional metal forming processes which are used to form various tubular components. In this technique tubular component of different shape are formed by using internal pressure of fluid and axial compressive loads simultaneously to force a tubular blank to form the final parts in to given die cavity. The concept behind hydro forming is inner pressure and fluid feeding in to die cavity, where well-defined combination of these initials is crucial for the success of the process [11].

Based on IHBF technology [3,5] of spherical and ellipsoidal shells, a new method for manufacturing large elbow pipes was proposed by which a toroidal shell is first hydro-formed and then the

Hydro-formed toroidal shell is cut into several elbow pipes with the desired angle. Some experimental research has been conducted indicating the feasibility of this process. This paper further discusses the feasibility of IHBF technology and the ability of FE simulation to analyze and predict this forming process.

Benefits [2] that can be achieved by using such processes are:

Reduced tooling cast, part density resulting in weight reduction, improved stiffness and structural strength, improved dimensional accuracy, minimum scrap rate, and weight reduction by efficient section design and tailoring the wall thickness.

Mass/Operation savings, Inexpensive tooling /complex parts produced in one single tool, Versatility in forming complex shapes and irregular contours, Minimal material thin out, Fewer operations required, Savings in tool materials, Fast tool changes, Savings in finishing costs, Materials versatility, Exceptional tolerance / higher precision of the part, Increased possibilities for product design coupled with ease of design change, Higher structural strength of the part / low work hardening, Minimal spring back

METHODOLOGY

In this section the [1] structure of the polyhedral toroidal shell prior to hydro-forming is generated in CAD software and the dimensions are same as in the paper. The medium radius of the elbow pipe R_0= 150 mm, the radius of the pipe r_0= 50 mm, and the wall thickness t = 1.5 mm.

The cross-section of the polyhedral toroidal shell is a hexagonal. The polyhedral toroidal shell was composed of four kinds of sub-shells: sub shell A-a cylindrical shell subjected to external pressure; sub-shell B-a conical shell subjected to external pressure; sub-shell C-a conical shell subjected to internal shell; and sub-shell D-a cylindrical shell subjected to internal pressure. According to structural symmetry, half of a quarter of the polyhedral toroidal shell was taken as a finite element model.

The shell material is mild steel commonly used in China for manufacturing pressure vessels and pipes. Examples include the stamping of automobile components [10], conventional deep drawing [7], tube hydro-forming [6] and hydro-forming of spherical vessels [4].

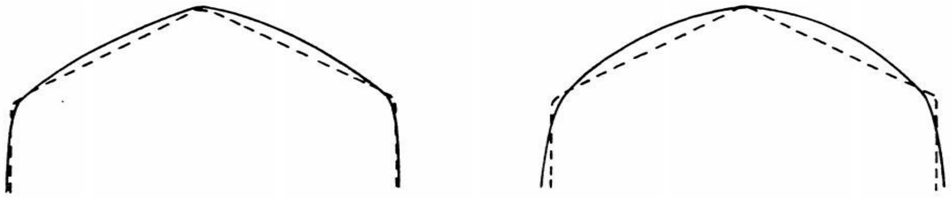
Its mechanical properties are shown in Table 1

Table 1.Mechanical properties of the shell material Mild-steel

Elastic modulus E (MPa)	Poisson's ratio n	Strength coefficient K in $\sigma = K\epsilon^n (MPa)$	Strain hardening exponent n
2.08×10^5	0.28	648.0	0.20

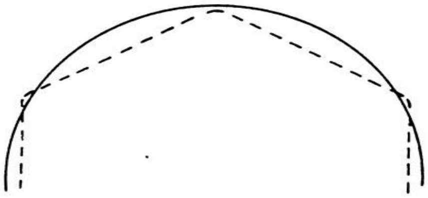
The code used for this finite element analysis was eat/DYNAFORM. It was specifically developed for sheet metal forming simulation and is an integrated pre and post processor and finite element solver, LS/DYNA. LS/DYNA is an explicit, dynamic finite element code which has been applied in many sheet metal forming problems. Hyper Mesh is a high-performance finite element pre-processor to prepare even the largest models, starting from import of CAD geometry to exporting an analysis run for various disciplines. Hyper Mesh enables engineers to receive high quality meshes with maximum accuracy in the shortest time possible. A complete set of geometry editing tools helps to efficiently prepare CAD models for the meshing process. Meshing algorithms for shell and solid elements provide full level of control or can be used in automatic mode. Mesh generation refers to the generation of nodal coordinate's nodes and elements. It also includes the automatic numbering of nodes and elements based on a minimal amount of user supplied data. Mesh generation in solid models can be semi- automatic due to availability of both geometrical and topological information.

RESULT AND DISCUSSION



(a) Initial stage p=2.0MPa

(b) Middle stage p=5.0MPa



(c) Final stage p=80.0MPa

Fig.2.1 Profile variation of section (a) Initial stage, *p* = 2.0 MPa; (b) middle stage, *p* = 5.0 MPa; (c) final stage, *p*= 8.0 MPa.

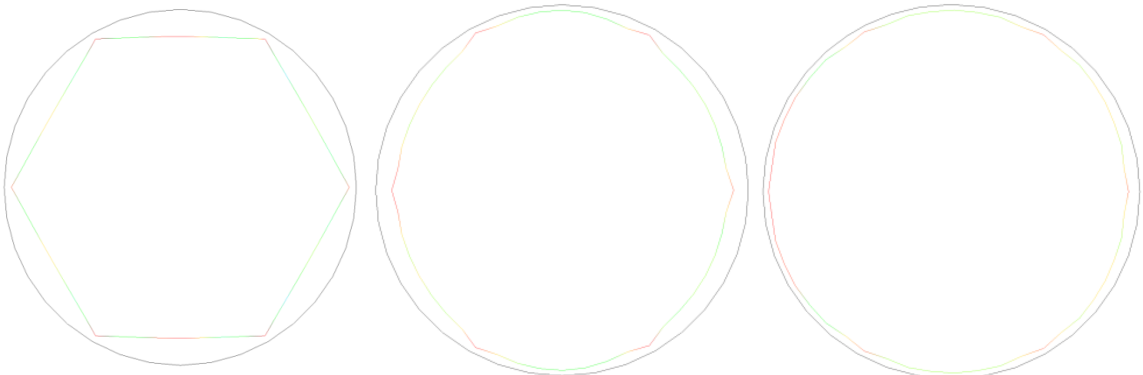
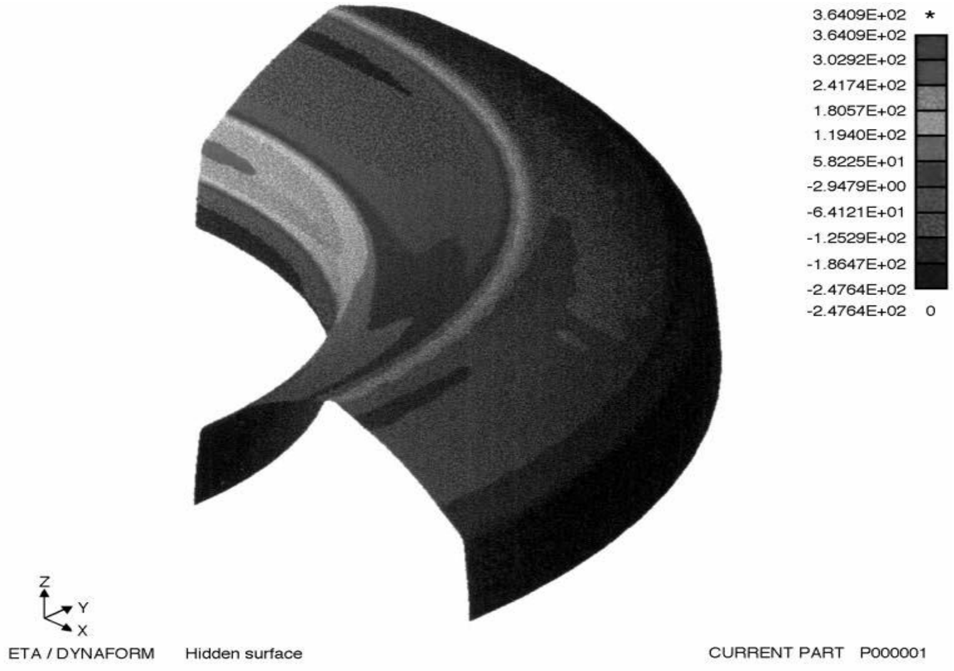
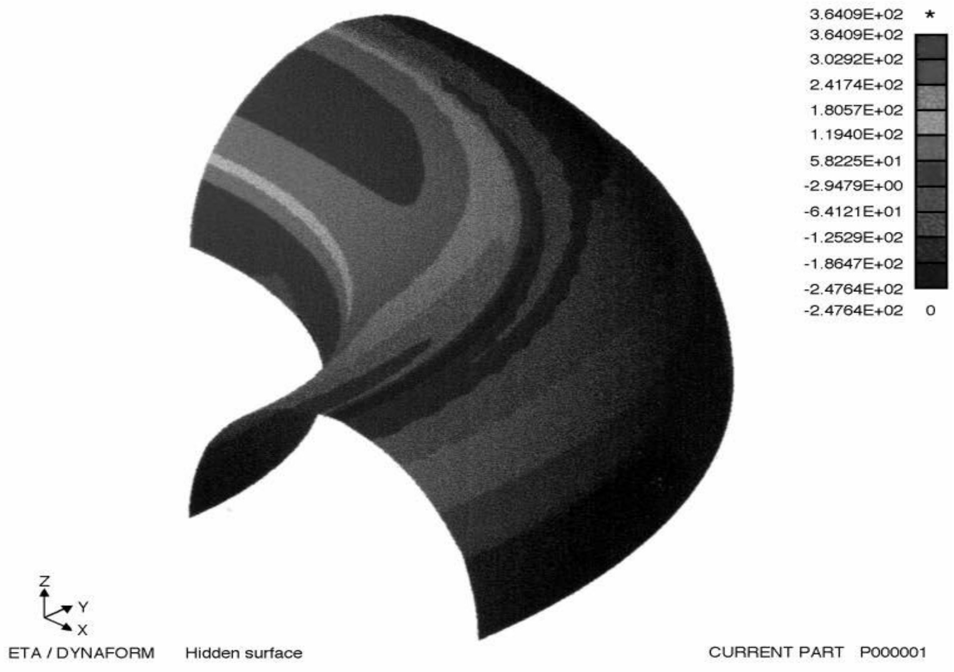


Fig.2.2 (a) Initial stage p=2 MPa, (b) Middle stage p=5 MPa & (c) Final stage p=8 MPa

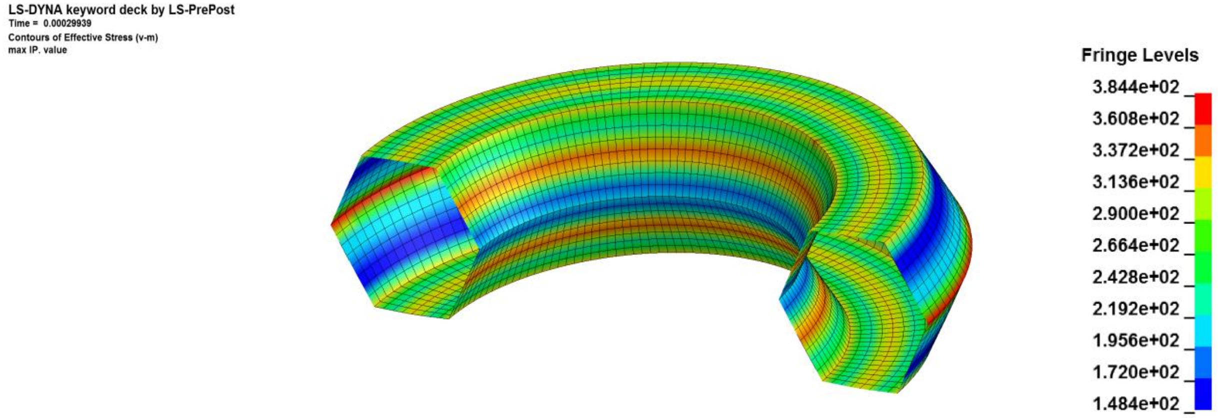


(a) Initial stage p=2.0MPa



(b) Final stage p=8.0MPa

Fig.2.3 Distribution of stress (unit: MPa) (a) Initial stage, *p* = 2.0 MPa; (b) final stage, *p* = 8.0 MPa.



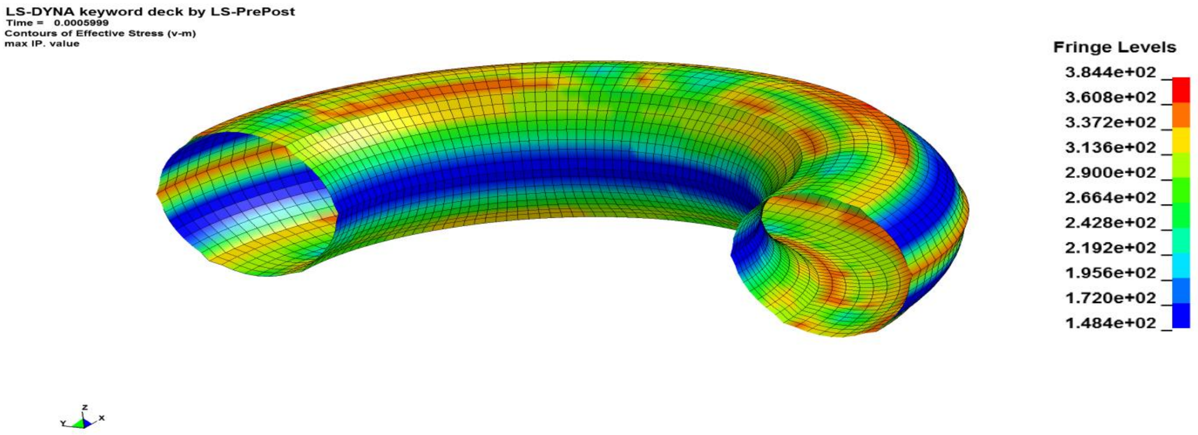


Fig.2.4 Distribution of stress (unit: MPa) (a) Initial stage, *p* = 2.0 MPa; (b) Final stage, *p* = 8.0 MPa.

Distributions of the stress in initial and final hydro-forming stage are shown in the above Figures. It is necessary to identified that the stress components used in post processing in the present version of DYNAFORM are in the Cartesian coordinate system. However, it is usually more convenient to use the cylindrical coordinate system for representing and analyzing stresses in a tabular shell for an axis-symmetric rotation shell such as a hexagonal tabular shape, the stress components in meridional and circumferential direction are the same in every cross-section. They look different in every cross-section due to the different projection angle. In order to make clear this problem, the stress components in the area near the *X*–*Z* plane are used in the following analysis.

It can be seen from above Figures that the stress distribution is similar as discussed in the reference paper [1] and in this analysis. Here circumferential stress distribution same from initial stage to the final stage but the stress will change their position and location across the periphery of the tubular billet as shown in the above figures on various sub-shells is in tensile state during the entire hydro-forming process. The stress produced is in compressive mode on shell. The compressive circumferential stress becomes tensile stress from initial to final stage of hydro-forming as the polyhedral toroidal shell is finally formed into an ideal toroidal shell. The numeric value of the stresses on surface of the toroidal shell is compared with the reference paper [1]. As per the above discussion the stress distribution at different stages of pressure likes initial stage (at 2MPa) and final stage (at 8MPa) of the component during their manufacturing. It is clear from above that stress distribution along the surface of the tabular component values are similar from the initial to final stage but location is changes during the forming process.

Table: Comparison of numeric value of stress with the reference paper [1]

Stress value in previous paper (in MPa)	Stress in this analysis (in MPa)	Difference between the value	Percentage Difference in the values
384	364	20	5.21

So here difference in the values of the process parameter is 5.21% approx. this is good correlation between reference work and present work, this proof that our method is good to proceed with the parameters taken in this validation work like boundary condition, material properties etc. we may further work with this parameters for the process development.

CONCUSSION

This study helps us to analyze for stress distribution in circumferential direction of toroidal shell by using LS-DYNA software. After analysis it is found that here difference in the values of the process parameter is 5.21% approx. this is good correlation between reference work and present work, this proof that our method is good to proceed with the process parameters taken in this validation work like boundary condition, material properties etc. we may further work with this method for the process development.

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