ISSN 2395-1621

Hydro forming of Vehicle Chassis Frame with varying Blank holding loads by FEA & FTI

#1 Chinnababu Arangi

[1] chinnasdesign@gmail.com

[1] Dr.D.Y.Patil School of Engineering, Pune, India

ABSTRACT

Hydro forming is a cost-effective way of shaping ductile metals such as aluminium, brass, low alloy steel, and stainless steel into lightweight, structurally stiff and strong pieces. One of the largest applications of hydro forming is the Car industries, which makes use of the complex shapes possible by hydro forming to produce stronger, lighter, and more rigid anybody structures for vehicles.

This technique is particularly popular with the high-end sports car industry and is also frequently employed in the shaping of aluminium tubes for bicycle frames. Hydro forming is a special process of die forming that uses a high pressure hydraulic fluid to press room temperature working material into a die.

Hydro forming is done for tubular structure and sheet metal parts used in many areas. Finite element modelling and simulations of hydro forming sheet metal process and closed sections has been carried out with the emphasis on draw-in effect. For that used Finite Element Analysis (FEA) and Forming Technology (FTI) methods. A Finite element model is built to analysis the different stages of the hydro forming process under various blank holding forces.

Keywords— Hydro forming, Car Industries, Tubular Hydro Forming, Sheet Hydro forming, Forming Technology.

ARTICLE INFO

Article History

Received :18th November 2015

Received in revised form :

19th November 2015

Accepted : 21st November , 2015

Published online :

22nd November 2015

I. INTRODUCTION

Hydroform is a popular word in sheet metal industry and tube forming industry. Hydroforming process is used for strengthening of the metal, hydromolding also produced less "grainy" parts, allowing for easier metal finishing. In Hydroforming process high pressurised oil and water are used to form a metal.

Sheet-forming process include a very large variety of shapes and sizes, ranging from simple bends to double curvatures with shallow or deep recesses and even very complex shapes. Typical examples are automobile bodies, aircraft panels, appliance bodies, kitchen utensils and beverage cans. Sheet metal process and tube forming process may gives the fair idea about the strategy of metal forming process.

In that, Hydroforming help us to give simplify of operations with light weight structure and complex geometry. In 1970's that rapid development of computer technology and finite element techniques made computed aided design and manufacturing technology (CAD/CAM) available to industry. At present, a great deal of effort is being made to implement CAD/CAM technology in sheet-metal forming industry, such as the auto industry, aerospace and aircraft manufacturing industries.

he implementation of computer-aided design and manufacturing technology assist the manufacturing industry significantly in reducing the cost, shortening the cycle time for developing new products and improving both quality and productivity.

Today, the study of sheet-metal forming technology tends to focus more on the following aspects:

1) To discover techniques that can determine the formability of sheet metals under various conditions.

© 2015, IERJ All Rights Reserved

2) To develop and control various metal textures to improve formability.

3) To implement computer aided die design and manufacturing to reduce costs andImprove quality and productivity.
4) To implement automated system to change press dies quickly.

Sheet metal is often produced by a rolling process. Before a sheet-metal part is formed, a blank of suitable dimension is removed from a large sheet with shearing process. Sheet metal forming involves many different processes, equipment and practice. The major processes can be classified as the following:
1) Shearing.
2) Beading, flanging, hemming and seaming.
3) Bulging.
4) Deep drawing and stretch forming.
5) Rubber forming (Guerin process, Verson-Wheelon Process, Marform process, Hydroform process)
6) Spinning (conventional spinning, shear spinning, tub Spinning)

7) High-energy-rate forming (explosive forming, Electrohydraulic forming, magnetic - pulse forming)
8) Super plastic forming.

II. LITERATURE SURVEY

Xiao-Lei Cui (2014) developed numerical simulation using the Abaqus/Explicit software. It is shown that increasing of external pressure has an effect on the fraction of grain boundaries, the number and size of the micro voids and the micro hardness in the transition zone, and thus increases the critical effective strain in the transition zone. It can be concluded that the deformation ability of the transition zone is improved by the external pressure in double-sided tube hydroforming of square-section. This investigation shows that double-sided tube hydroforming is a potential forming method for the fabrication of lightweight hollow structures using the tubes with low ductility. [1]
Ali Khalfallah (2014) The identification of welded tubes properties considering the weld bead and Heat Affected Zone (HAZ) is important for reliable and accurate finite element simulation of tubular plastic forming processes such as tube hydroforming and rotary draw bending processes. Therefore, a simplified method is proposed to extract the weld bead and HAZ properties. Full size standard tensile specimens cut from the welded tube and comprising the weld parallel to the load direction are extended to failure. Mechanical properties obtained from uniaxial tensile test are correlated with the microhardness data measured across the welded specimen and by using the rule of mixtures; the constitutive model parameters of weld bead and HAZ regions are identified. Accuracy of the proposed method is assessed by comparing finite element simulation predictions to experimental measurements obtained from two mechanical tests: the first one is the uniaxial tensile test performed on specimens comprising the weld line perpendicular to the loading direction and the second test is the free bulge hydroforming test achieved on seamed tubular samples.This investigation has shown that the presented method is practical in use and sufficiently accurate to extract the weld metal properties of seamed tubes. [2]

Feifei Zhang, (2014) The M–K method has been used with Barlat's1989 anisotropic yield surface to predicate forming limit to study the effect of the normal stress and material anisotropy. The 3D stress state is converted to plane- stress state according to the hypothesis that hydrostatic stress has no effect on plastic deformation. The predicted forming limits correlate well with experimental data for AA5XXX under plane-stress condition and AA6011 aluminum alloy under three-dimension stress condition. Analyses show that normal stress increases the forming limit described both ins train space and in stress space. Moreover, the sensitivity of forming limit curve to normal stress is associated with the material's hardening effect. [3]

Temim Zribi, (2013) determined the constitutive parameters of tubular materials made of low carbon steel S235 and aluminum alloy AA6063-O. For this purpose, a new self-designed bulge forming machine is manufactured to perform tubular bulge tests. Additionally, tensile tests are carried out on specimens cut from the tube to measure the Lankford anisotropy coefficients. The proposed inverse identification method is developed to identify efficiently the flow stress parameters consider ing material anisotropy effects. This method is made up of an optimization algorithm that con- nects experimental free bulge test results and finite element analysis. The comparison between predicted results and experimental data is performe d to assess the proposed approach. It is shown that this iden- tification strategy provides appropriate flow stress relationship which can be used to predict accurate plastic deformation beh avior during the tube hydroforming process. [4]

Xianfeng Chen, (2011) developed a new theoretical model to predict the FLD for a seamed tube hydroforming. Based on this theoretical model, the FLD for a seamed tube made of QSTE340 sheet metal is calculated by using the Hosford yield criterion. Some forming limit experiments are performed. A classical free hydroforming tool set is used for obtaining the left hand side forming limit strains, and a novel hydroforming tool set is designed for the right hand side of FLD. The novel device required the simultaneous application of lateral compression
force and internal pressure to control the material flow under tension–tension strain states. Furthermore, the suitable loading paths for the left hand side of FLD by theoretical formulas and for the right hand side of FLD by finite element (FE) simulations are calculated. Finally, a comparison between the theoretical results and experimental data is performed. The theoretical predicting results show good agreement with the experimental results. [5]

G. Palumbo et al., (2006) focused in the adoption of a movable inferior plate through which the control of the blank forming is realised. Tests on hemitoroidal parts using an innovative equipment with a movable die were carried on at the Institute of Metal Research (Chinese Academy of Sciences) in cooperation with the Aalborg University, putting in evidence main defects and fracture causes. Finite element simulations of the modified hydroforming process

© 2015, IERJ All Rights Reserved

using a movable inferior plate were performed at the Centre of Excellence for Mechanical Computation (Polytechnic of Bari), with the aim of evaluating critical strain values and their location, strain paths, load curves and stress maps were analysed. Specimens with proper geometrical shape were designed to avoid possible ruptures and to reduce material thinning in the critical regions. [6]

L.H. Lang et al. (2004), hydroforming technology is used widely for forming lightweight or complicated components in the automotive industry and aerospace industry, etc. Recent developments and the character of hydroforming, especially sheet hydroforming and tube hydroforming, also known by the name of internal high pressure forming, are discussed in detail. Based on applications and by using liquid as a forming media, the state of the art and key technologies concerned with equipment, process control, simulation, etc. are explored in detail. Conclusions are drawn concerning possible future developments in hydroforming technology. [7]

M. Brunet, (2004) developed numerical and experimental study of failure for tubular hydroforming under combined axial force and internal pressure. In this forming process, two distinct failure modes occur, the necking or bursting and the wrinkling or buckling. The originality of the study presented is that these two phenomena are considered in an unified approach based on the rate of internal and external powers. The governing equations for the onset of both failure modes are established. Two local criteria are derived in the context of explicit codes and compared to experimental results obtained from the hydroforming of a stainless tube. [8]

Z.R. Wang, (2004) developed numerical simulations of the integral hydroforming of shell products, the hydroforming process of tubular products and the viscous pressure forming of a super alloy corrugated part are reported. The simulations were conducted using the explicit finite-element code LS-DYNA and the code DEFORM. [9]

L.M. Smith (2003) compared six different formability models in light of their sensitivity to thickness normal stress ($\sigma3$) and other process variables associated with THF. It is shown that the models which capture the $\sigma3$ effect are most suitable for formability assessment for the double-sided high-pressure (DSHP) process. The stress space forming limit model is then employed in the context of a solid finite element model of a plane-strain THF expansion. The presence of the DSHP boundary condition is shown to lead to increased formability relative to that observed for the traditional single-sided high-pressure (SSHP) process. Research of the DSHP process may lead to discoveries of various avenues towards greater formability. Consequently, the design space currently available to those employing the SSHP process may be significantly increased through the DSHP process. Ultimately, such design space increase may result in lower product cost, greater customer enthusiasm and increased market share for those manufacturers who invest in the DSHP process. [10]

Muammer Koc¸ (2001) Increasing acceptance and use of hydroforming technology within the automotive industry demands a comprehensive understanding of related issues such as material characteristics, tribology, part and tooling design. Among these issues, characterization and specification of tubular material properties under hydroforming conditions is the main concern of this paper. Analytical improvements and their comparison with experimental findings on measurement of material properties of tubes under hydraulic bulging conditions are explained. With these improvements, 'on-line' and continuous measurement of flow stress for tubular

Materials become possible, and are proven to be in good agreement with previous 'off-line' measurements. [11]

P. Hein and F. Vollertsen, (1999) presented a new class of hydroforming processes, they are characterized by the use of sheet metal pairs, thus allowing an extended variety of shapes, but they require special sealing and docking devices. Models, simulations and experiments have concentrated on the feasibility of one particular process (the hydroforming of unwelded sheet metal pairs) and on the influence of the various parameters on the process window as well as on the part geometry. [12]

DEL PRETE Antonio, Checked the developed methodology through an application on an industrial test case characterized by a complex geometry and called " Fondello Fanale". Starting from the geometry of the industrial test case, it is possible to say that more than one of the shape factors is needed to analyze the product feasibility. On the considered component the most critical areas have been chosen by the authors taking into account the component shape. In each one of the considered areas, the shape factors have been calculated and their value have been compared with their physical limit. The shape factors analysis has led to declare the no feasibility of the FF.In compliance with the shape factors rules three new and different geometries have been identified and numerically tested in order to verify their feasibility. [13]

Nader Abedrabbo et al., An approach is presented to optimize a tube hydroforming process using a Genetic Algorithm (GA) search method. The goal of the study is to maximize formability by identifying the optimal internal hydraulic pressure and feed rate while satisfying the forming limit diagram (FLD). The optimization software HEEDS is used in combination with the nonlinear structural finite element code LS-DYNA to carry out the investigation. In particular, a sub-region of a circular tube blank is formed into a square die. Compared to the best results of a manual optimization procedure, a 55% increase in expansion was achieved when using the pressure and feed profiles identified by the automated optimization procedure. [14].

III. DETAILS OF ACTUAL COMPONENT

The work is carried out on Commercial vehicle chassis frame. This process made of Tube hydro forming.
Existing design is assembled with 'C' Channel as shown in fig1.

© 2015, IERJ All Rights Reserved

Fig1: Actual Chassis long member

A) Geometry of Hydroforming long member:

The cad model design of Chassis long member done by CATIAV5R19 software. The cad model as shown in the fig2. The following dimensions was listed table1.

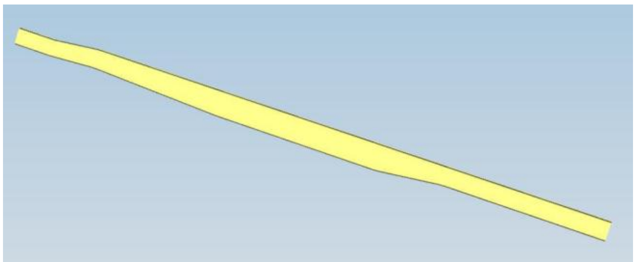

Fig2. Cad Model of Long members

Table1:

S.NO	Parameter	Length(mm)
1	Length of Long member	4300
2	Width of cross section	60
3	Height of Cross section	190
4	Thickness of the tube	3.15

B) Material and properties of E48

All E48 material properties collected on ANSYS software library. The material and properties tabulated on the table2.

Table2:

Sr. No	Properties	Value
1	Yield stress KN/mm^2	0.460
2	Ultimate stress KN/mm^2	0.520
3	%Elongation	25%
4	Plastic strain at failure	22%

IV. FINITE ELEMENT ANALYSIS:

Table3: First 6 Rigid Body modes frequency values:

Mode No.	Frequency value (Hz)
1	11.72
2	21.50
3	31.15
4	39.30
5	43.15
6	49.89

Mode Shapes for Chassis frame:

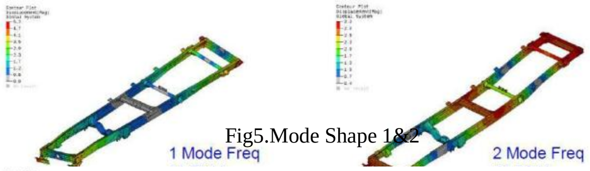

Fig5.Mode Shape 1&2

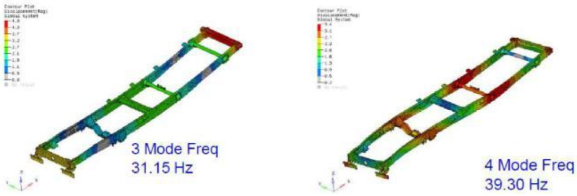

Fig6.Mode Shape 3&4

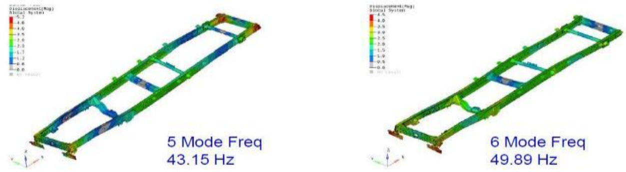

Fig7.Mode Shape 5&6

V. RESULTS AND DISCUSSIONS:

Comparison Table: As per FEA results.
The comparison values listed inTable4.

Table4: Mode shapes & model frequencies of existing and modified Hydroforming frame:

Mode No.	Existing Frame Frequency value (Hz)	Modified Hydroforming Frame Frequency value(Hz)	Mode Shape
1	12.71	11.72	Torsional mode
2	18.67	21.50	Lateral bending mode
3	25.57	31.15	Vertical bending mode
4	33.53	39.90	Torsional mode
5	46.11	43.15	Lateral bending mode
6	51.58	49.89	Vertical bending mode

Table5: Stiffness results of the frame:

S No.	Parameters	Existing Frame	Modified Hydroforming Frame
1	Torsional stiffness front	464.440	505.906
2	Torsional stiffness rear	464.437	506.128
3	Vertical bending stiffness	3.319	3.584
4	Front lateral bending	0.101	0.150
5	Rear lateral bending	0.095	0.142

© 2015, IERJ All Rights Reserved

VI. CONCLUSIONS

In this investigation, the hydroforming of axisymmetric sheet metal with different blank holding conditions has been simulated in finite element method. The elasto-plastic finite element package has been used to calculate the large element package used to calculate the large plastic deformation. Comparison has been made between the simulation results and the experimental results

Based on the verified modeling, the effects of draw-in on the hydroforming process have been analyzed. It is observed that during hydroforming process the deformation in the workpiece is nearly a balanced biaxial stretching. Draw-in results in little effect on the strain state in the workpiece in the hydroforming process. The severity of deformation in the blank may be reduced by the draw-in action. Because of its higher threshold strain, the balanced biaxial stretching is a state which is expected in sheet metal forming process. With greater draw-in, a higher polar height can be achieved. The formality which is represented by the limiting of thickness strain at critical section Et * remains substantially constant under different draw-in conditions. This enables us to take the advantage of the reduction of deformation and better uniformity of thickness due to the draw-in action. The disadvantageous effect of draw -in is the tendency of wrinkling of the blank at the die shoulder area. By varying the blank holding load during the forming process, the material flow of draw -in can be controlled and the strain path of the material at the die shoulder area can be changed so that the contractive circumferential strain which may cause wrinkling can be slightly reduced. The theoretical solution based on incremental theory of plasticity and the finite difference methods used in this approach have also been discussed. It can be seen that difficulty occurs when the draw-in boundary conditions are imposed.

ACKNOWLEDGEMENT

First of all I express my sincere thanks and the deepest sense of gratitude to my guide Prof. A.P. Deshmukh, Mechanical Engineering Department for his constant inspiration, encouragement and invaluable suggestions for the successful completion of my Project Stage-I&II.

I express my heart full thanks to Prof. P.A. Makasare, Head of the department, Mechanical Engineering and our P.G Co-ordinator Prof. A.N. Patil for the creative environment has provided to my work.

Last but not the least, I extend my sincere thanks to my professors and friends without whose help, encouragement and active participation this Project Stage-I work would not have been a success.

REFRENCES

[1] Xiao-Lei Cui, Xiao-Song Wang & Shi-Jian Yuan, (2014) "Deformation analysis of double-sided tube hydroforming in square-section die", Journal of Materials Processing Technology, Volume 214, Pages 1341– 1351.

[2] Ali Khalfallah, (2014) "Experimental and numerical assessment of mechanical properties of welded tubes for hydroforming", Materials and Design, Volume 56, Pages 782–790.

[3] FeifeiZhang, JieshiChen, JunChen & XinhaiZhu, (2014) "Forming limit model evaluation for anisotropic sheet metals under through-thickness normal stress", International Journal of Mechanical Sciences, Volume 89, Pages 40–46.

[4] Temim Zribi, Ali Khalfallah & Hedi BelHadjSalah, (2013) "Experimental characterization and inverse constitutive parameters identification of tubular materials for tube hydroforming process", Materials and Design, Volume 49, Pages 866–877.

[5] Xianfeng Chen, Zhongqi Yu, Bo Hou, Shuhui Li & Zhongqin Lin, (2011) "A theoretical and experimental study on forming limit diagram for a seamed tube hydroforming", Journal of Materials Processing Technology, Volume 211, Pages 2012– 2021.

[6] G. Palumboa, S.H. Zhangb, L. Tricaricoa, C. Xub & L.X. Zhouc, (2006) "Numerical /experimental investigations for enhancing the sheet hydroforming process", International Journal of Machine Tools & Manufacture, Volume 46, Pages 1212–1221.

[7] L.H. Lang, Z.R. Wang, D.C. Kang, S.J. Yuan, S.H. Zhang, J. Danckert & K.B. Nielsen, (2004) " Hydroforming highlights: sheet hydroforming and tube hydroforming", Journal of Materials Processing Technology, Volume 151, Pages 165–177.

[8] M. Brunet, S. Boumaiza & G. Nefussi, (2004) "Unified failure analysis for tubular hydroforming", Journal of Materials Processing Technology, Volume 148 Pages 269–277

[9] Z.R. Wang, B.G. Teng, S.J. Yuan, L.H. Lang & Z.J. Wang, (2004) "Simulation of some cases of hydroforming and viscous pressure forming", Journal of Materials Processing Technology, Volume 150 Pages 25–29.

[10] L.M. Smith, S. Ganeshmurthy & K. Alladi, (2003) "Double-sided high-pressure tubular hydroforming", Journal of Materials Processing Technology, Volume 142, Pages 599–608.

[11] Muammer Koc¸ Yingyot Aue-u-lan & Taylan Altan, (2001) "On the characteristics of tubular materials for hydroforming experimentation and analysis", International Journal of Machine Tools & Manufacture, Volume 41 Pages 761–772

[12] P. Hein & F. Vollertsen, (1999) "Hydroforming of sheet metal pairs", Journal of Materials Processing Technology, Volume 87 Pages 154– 164.

© 2015, IERJ All Rights Reserved