Glance of Hydroforming of Tubular Structure and Sheet Metal with Varing Blank Holding Loads by FEA & FTI

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Strictly as per the compliance and regulations of :

Glance of Hydroforming of Tubular Structure and Sheet Metal with Varing Blank Holding Loads by FEA & FTI

Rakesh Jadhav [α] & Tippa Bhimasankara Rao [σ]

Abstract - Hydroforming is a cost-effective way of shaping ductile metals suchas aluminium, brass, low alloysteel, stainless steel into lightweight, structurally stiff and strong pieces. One of the largest applications of hydro forming is the automotive industry, 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 specialized type of die forming that uses a high pressure hydraulic fluid to press room temperature working material into a die. Hydroforming is done for tubular structure and sheet metal also. Finite element modeling and simulations of hydroforming sheet metal process and closed sections has been carried out with the emphasis on draw-in effect. For that used FEA and FTI methods. A Finite element model is built to simulate the different stages of the hydroforming process under various blank holding forces.

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I. Introduction

Hydroform is a popular word in sheet metal industry and tube forming industry. Hydro forming process is used for strengthening of the metal, hydramolding 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.

The 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.

II. Main Process Variants

a) Sheet Hydroforming

This process is based on the 1950s patent for hydramolding by Fred Leuthesser, Jr. and John Fox of the Schaible Company of Cincinnati, OH it was originally used in producing kitchen spouts. This was done because in addition to the more strength.

In sheet hydroforming there are bladder forming (where there is a bladder that contains the liquid; no liquid contacts the sheet) and hydroforming where the fluid contacts the sheet (no bladder). Bladder forming is sometimes called flex forming Flex forming is mostly used for low volume productions, as in the aerospace field. Forming with the fluid in direct contact with the part can be done either with a male solid punch (this version is sometimes called hydro-mechanical deep drawing) or with a female solid die.

In hydro-mechanical deep drawing, a work piece is placed on a draw ring (blank holder) over a male punch then a hydraulic chamber surrounds the work piece and a relatively low initial pressure seats the work piece against the punch. The punch then is raised into the hydraulic chamber and pressure is increased to as high as 15000 psi which forms the part around the punch. Then the pressure is released and punch retracted, hydraulic chamber lifted, and the process is complete.

For large parts, explosive hydroforming can generate the forming pressure by simply exploding a charge above the part (complete with evacuated mold) which is immersed in a pool of water. The tooling can be much cheaper than what would be required for any press-type process. The hydroforming into a mold-process also works using only a shock wave in air as the

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pressuring medium. Particularly when the explosives are close to the work piece, inertia effects make the result more complicated than forming by hydrostatic pressure alone.

b) Tube Hydroforming

In tube hydroforming there are two major practices: high pressure and low pressure. With the high pressure process the tube is fully enclosed in a die prior to pressurization of the tube. In low pressure the tube is slightly pressurized to a fixed volume during the closing of the die (this used to be called the Variform process). Historically, the process was patented in the but it was industrially spread in the '70s for the production of large T-shaped joints for the oil & gas industry.

Today it is mostly used in the automotive sector, where many industrial applications can be found. It is also a method of choice for several tubular members of bicycles. In tube hydroforming pressure is applied to the inside of a tube that is held by dies with the desired cross sections and forms. When the dies are closed, the tube ends are sealed by axial punches and the tube is filled with hydraulic fluid.

The internal pressure can go up to a few thousands of bars and it causes the tube to calibrate against the dies. The fluid is injected into the tube through one of the two axial punches. Axial punches are movable and their action is required to provide axial compression and to feed material towards the center of the bulging tube. Transverse counterpunches may also be incorporated in the forming die in order to form protrusions with small diameter/length ratio. Transverse counterpunches may also be used to punch holes in the work piece at the end of the forming process. Designing the process might be a very challenging task, since analytical modelling is possible only for very simples cases.Often FEM simulations must be performed in order to find a feasible process solution and to define the correct loading curves: pressure vs. time and axial feed Vs time.

III. SHEET METAL ASPECTS

a) Formability Describes The Capacity Of The Sheet Metal To Be Formed Into Designed Shape Without Necking And Fracture. Unlike In The Bulk Deformation Process, Work Pieces In Sheet Forming Are Manipulated To Prevent Reduction In The Cross-Sectional Area So As To Avoid Necking And Fracture.
b) Buckling Or Wrinkling Does Not Only Cause Another Type Of Failure Of The Products, But Also Brings Difficulties In The Theoretical Aspect.
c) Surface Finish Is Another Significant Factor Since Parts Formed By Sheet Forming Processes Are Generally Not Subjected To Further Processing, Except For Surface Coating, Parting And Joining.

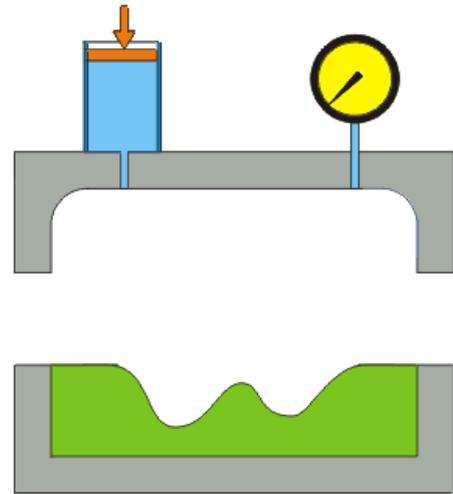d) Spring Back May Affect The Final Shape Of The Product, Especially When More Bending Is Involved In The Operation.
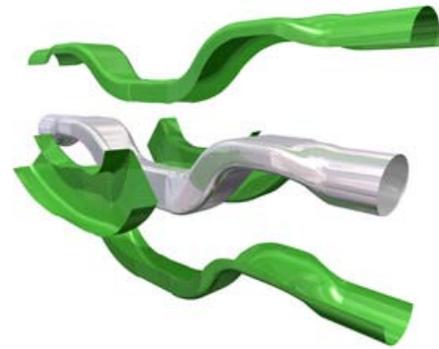

Figure 1

Figure 2

In hydro forming process, liquid is used as medium of energy transfer to form the workpiece. There are essentially two different types of applications of the liquid pressure: Hydraulic die and Hydraulic punch. In this paper, only the hydraulic punch forming process will be discussed. A typical equipment used for this process.

In *Figure* (3), the blank is clamped by the upper blank holder and lower die which can be either plane or serrated (rough surface).The blank holding load can be controlled by the clamping bolts 1 Pressured liquid enters the room A and force the blank to deform against the solid die 2, so that the desirable shape can be Achieved.
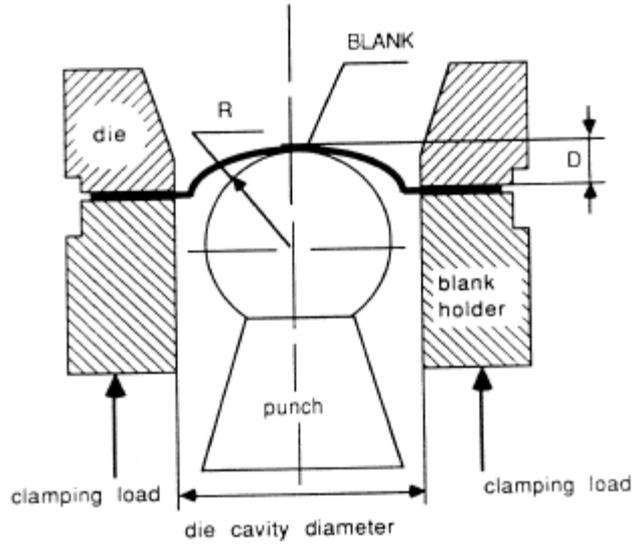
Figure 3 : Schematic illustration of Erichsen Test

The coordinates and displacement used in the axisymmetrical sheet forming process are defined as following: a point P in the blank with a initial distance are moves to the coordinate (r + Llr, y).s is the curvature coordinate.

T is the surface normal.
E is the circumferential coordinate

Three principle strains are:
Circumferential strain $Ea = \log_e [(r+r)/r]$
meridional tangential strain $Es = \log_e [ds/dr]$
Through thickness strain $Et = \log_e (t/t0)$
meridional tangential strain $Es = \log_e [ds/dr]$
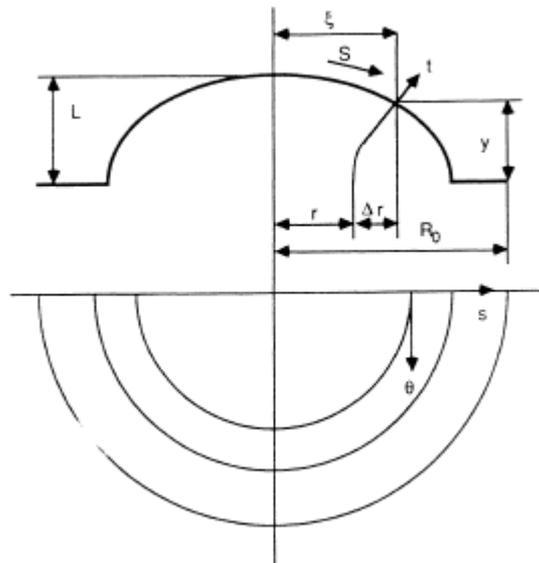Through thickness strain $Et = \log_e (t/t0)$

Figure 4 : Coordinates and displacement in axisymmetric sheet forming process

In order to exhibit the draw-in effect on the sheet metal forming process, it is necessary to define the measure of draw- in. Kaftanoglu and Alexander [4] used the circumferential strain that occurs at the inside diameter or bore of the blank-holder to define the quantity of draw-in. When the draw-in of the flange is totally prevented, the £a * is zero. But, once the draw-in occurs, the E * becomes compressive and numerically larger. Hence, reflect the actual local draw-in quality.

Lets see al introduced a draw-in parameter q> by measuring the movement of the flange. In Fig (5), DD is the die opening line;

BB is the blank outline

CC is defined as when polar height

L is attained, the material on CC of the undeformed blank reaches the die opening line

DD. <p is defined in the form of strain

<p = loge (Ac / AD)

Ac and AD denote respectively the area inside the circle of CC

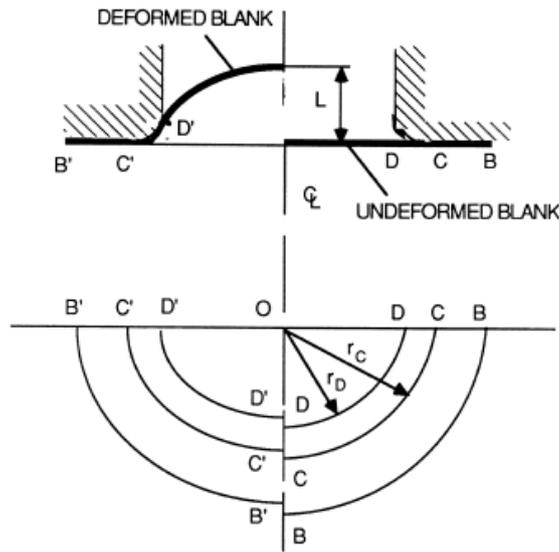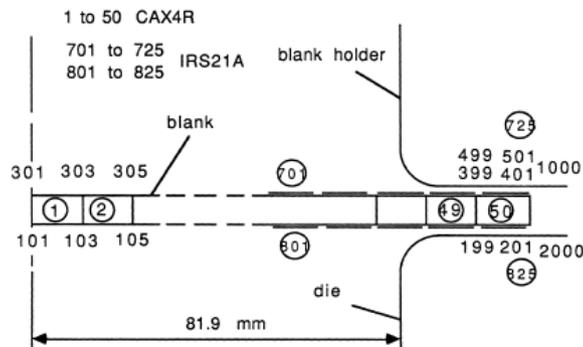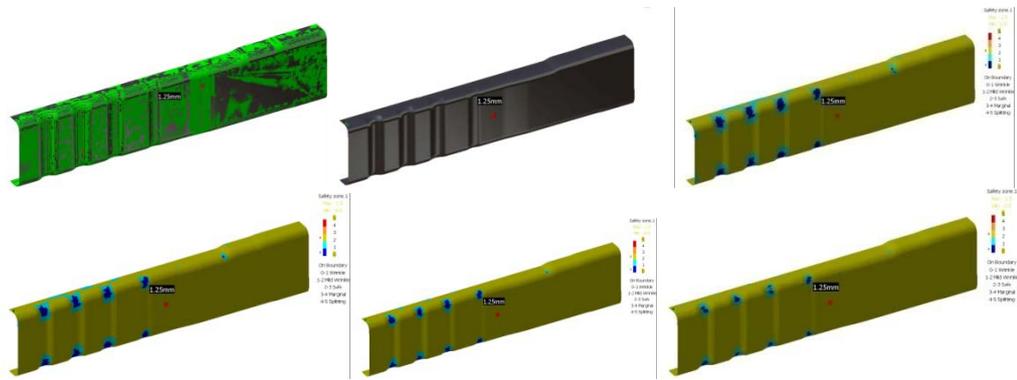and DD. <p reflects the overall draw-in quantity.

Figure 5 : Flange movement during the Blanking Process
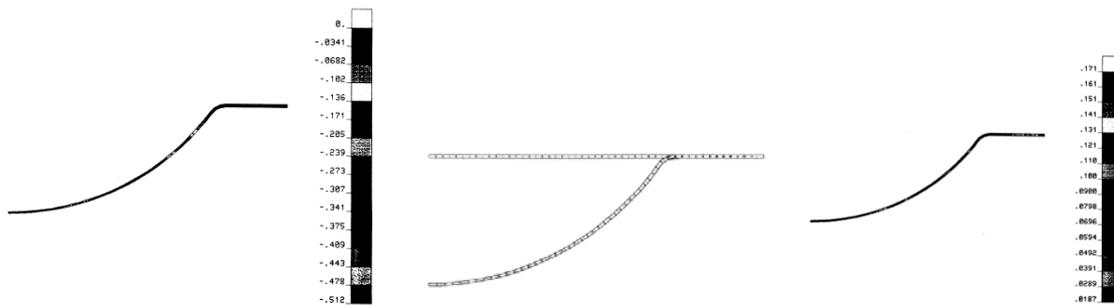
IV. CALCULATIONS & SIMULATION

Finite Element Modelling:-

Result (a): Simulation in FTI software-

Result (b):- Simulation in FEA-

£ = mIn[1- exp(-ne)] + k
Where E is the true strain defined as
£ =2/9 [(£1 - £2)2 + (£2 - £3)2 + (£3 - £1)2]0.5
o is the true strain
o=1, * [({j1- {j2)2 + ({j2- {j3)2 + (~- {j1)2]O.S

V. CONCLUSION

In this investigation, the hydro forming of Axis symmetric sheet metal with different blank holding conditions has been Simulated in FTI and Finite Element Method. The elastoplastic finite element package has been used to calculate the large plastic deformation. Comparison has been made between the simulation results and the experimental results and has a good agreement has been observed.

Based on the verified modelling, the effects of draw-in on the hydro forming process have been analysed. It is observed that during hydro forming process the deformation in the work piece is nearly a balancebiaxial stretching. Draw-in results in little effect on the strain state in the work piece in the hydro forming 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 thelimiting of thickness strain at critical section Et * remains substantially constant under different draw-in conditions.

In future research, it is suggested that experiments should be carried out for hydro forming process with varying blank load. Effort should be continued to explore how to further reduce the tendency of wrinkling at the die shoulder area. Concerning finite element simulation, a better shell element is needed the two side contact clamping condition.

VI. ACKNOWLEDGMENT

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