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Simulation of Tube Hydroforming Process for Seamless Tube by Using Finite Element Method

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ABSTRACT

In today's increasing competitive business environment, where every penny counts, product manufacturers are scrambling to maintain their market share and profitability. With cost, time and weight considerations dominating virtually every engineering discussion, efficient, innovative manufacturing methods are needed to reduce material consumption and cut production costs across the industry. Today, hydroforming is used to produce variety of components with consistently high levels of tensile strength and rigidity, optimized weight, accurate geometry and close tolerances.

In this project work, FEM simulation is carried out to find out forming pressure and effective punch stroke length in a tube hydroforming process. AA 6082- T4 material is used for the process.

1.0 INTRODUCTION

Hydroforming is a cost-effective way of shaping malleable metals such as aluminum or brass into lightweight, structurally stiff and strong pieces. One of the largest applications of hydroforming is the automotive industry, which makes use of the complex shapes possible by hydroforming 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 aluminum tubes for bicycle frames. Hydroforming is a specialized type of die forming that uses a high pressure hydraulic fluid to press room temperature working material into a die.

1.1 FACTORS AFFECTING THE TUBE HYDROFORMING PROCESS

As hydroforming becomes more widely used, several issues must be addressed to increase the implementation of this technology in the stamping industry. These issues include:

- Preparation of tubes, which involves material selection and quality of the incoming tube.
- Perform design and production method.
- Part design for hydroforming.
- Welding and assembly of hydroformed components - - that is, fixturing and joining.
- Crush performance and joint stiffness.
- Selection of a lubricant that does not break down at high pressures.
- Rapid process development.

2.0 PROBLEM DEFINITION

Seamless pipes for transporting mainly steam and oil under high temperature and high pressure are used for connections between boilers and steam turbines in power plants and transportation of distilling oil in refineries. Pipes with larger diameters help to raise operational efficiency in all facilities, while thinner walls enabled through the use of an alloy for extra hardness help to reduce construction costs in refineries and lower weight loads in power plants. In our case a Φ 65 mm tube with 250 mm length with 1.5 mm wall thickness is hydroformed to expand its diameter for a specified length. This process is simulated through FEM system with the help of Altair Hyperform & LS Dyna solver.

3.0 FINITE ELEMENT ANALYSIS

Finite Element Analysis (FEA) was first developed in 1943 by R. Courant, who utilized the Ritz method of numerical analysis and minimization of variational calculus to obtain approximate solutions to vibration systems. Shortly thereafter, a paper published in 1956 by M. J. Turner, R. W. Clough, H. C. Martin, and L. J. Topp established a broader definition of numerical analysis. The paper centered on the "stiffness and deflection of complex structures". By the early 70's, FEA was limited to expensive mainframe computers generally owned by the aeronautics, automotive, defense, and nuclear industries. Since the rapid decline in the cost of computers and the phenomenal increase in computing power, FEA has been developed to an incredible precision. Present day supercomputers are now able to produce accurate results for all kinds of parameters.

3.1 LS DYNA

LS-DYNA is an advanced general-purpose multiphysics simulation software package developed by the Livermore Software Technology Corporation (LSTC). While the package continues to contain more and more possibilities for the calculation of many complex, real world problems, its origins and core-competency lie in highly nonlinear transient dynamic finite element analysis (FEA) using explicit time integration. LS-DYNA is being used by the automobile, aerospace, construction, military, manufacturing, and bioengineering industries

4.0 ANALYSIS DETAILS

4.1 MECHANICAL PROPERTIES OF ALUMINUM 6082-T4

Aluminium alloy 6082 is a medium strength alloy with excellent corrosion resistance. It has the highest strength of the 6000 series alloys. Alloy 6082 is known as a structural alloy. In plate form, Aluminium alloy 6082 is the alloy most commonly used for machining. As a relatively new alloy, the higher strength of Aluminium alloy 6082 has seen it replace 6061 in many applications. The addition of a large amount of manganese controls the grain structure which in turn results in a stronger alloy.

Mechanical Properties of Aluminium alloy 6082

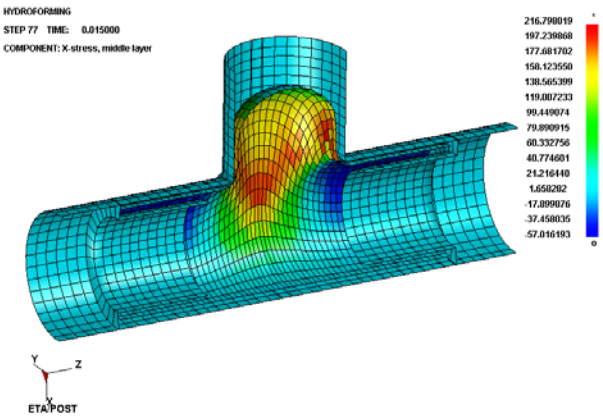
Tensile Strength (MPa)	260
Shear Strength (MPa)	170
Elongation A5 (%)	019
Hardness Vickers (HV)	075

4.2 ANALYSIS SETUP

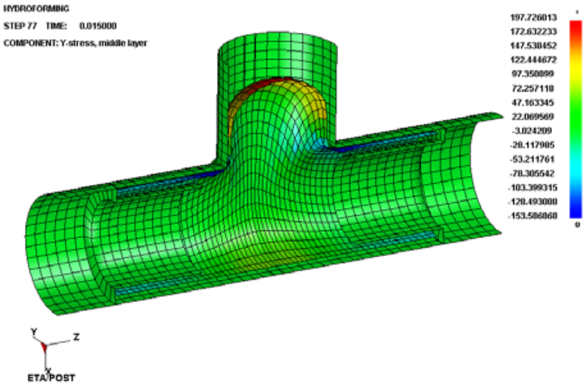
This problem includes two tools, a punch nose and a die tube. A blank tube is formed by blow molding the nose through the tube. The hollow tube blank is made with 600 shell elements and has an outer radius of 12 mm, an initial thickness of 1.37 mm, and an initial length of 53.5 mm. The internal pressure of the hollow tube blank is 40 N/mm2 applied. The tools are rigid shell elements. Only 1/4 of the system is modeled because of symmetry. The motion of the punch nose and the end of the blank follow a linear motion with a total displacement of 15 mm.

4.3 ANALYSIS DIAGRAMS

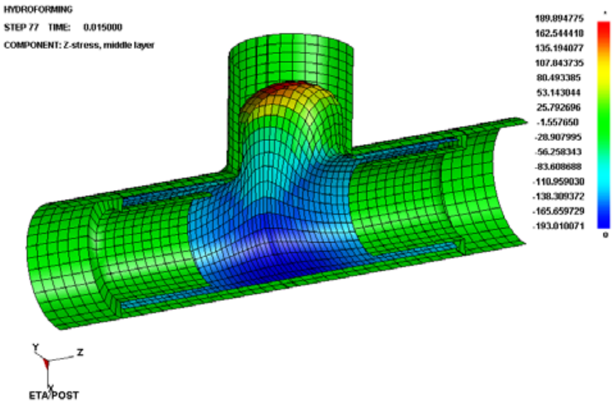
Sigma XX



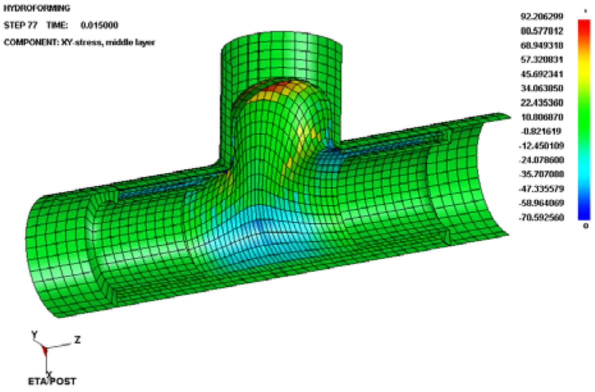
Sigma YY



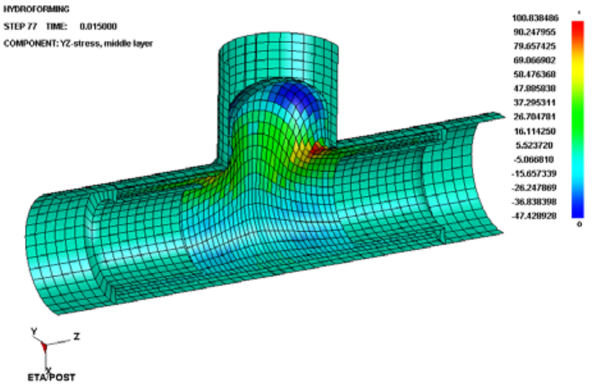
Sigma ZZ



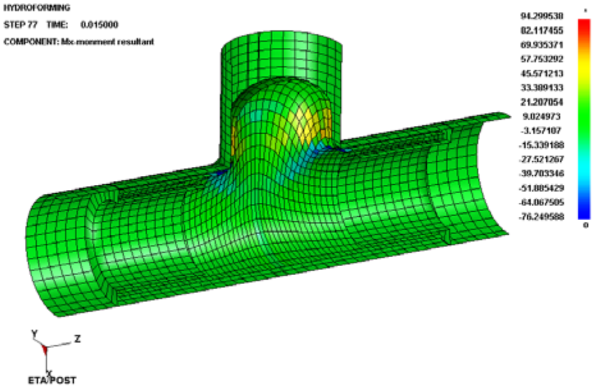
XY Stress



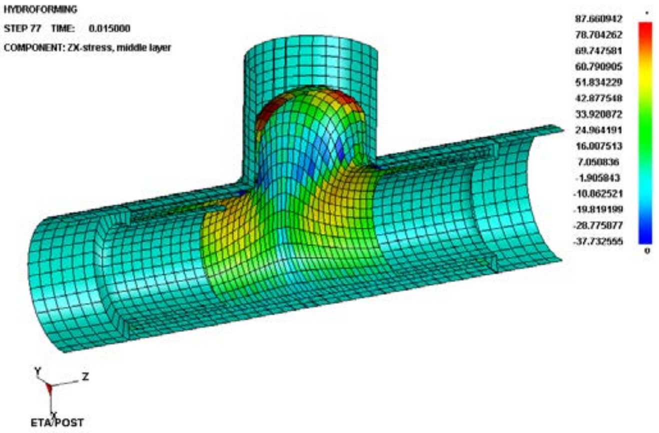
YZ Stress



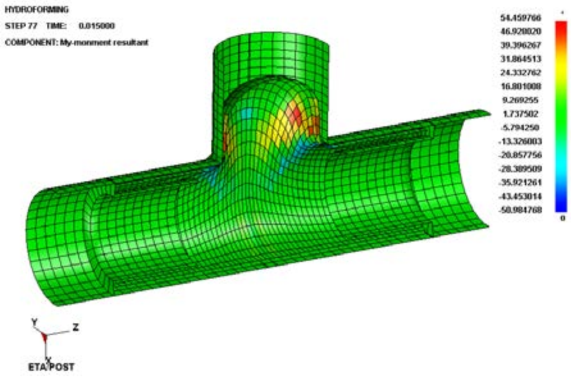
Mx Moment Result



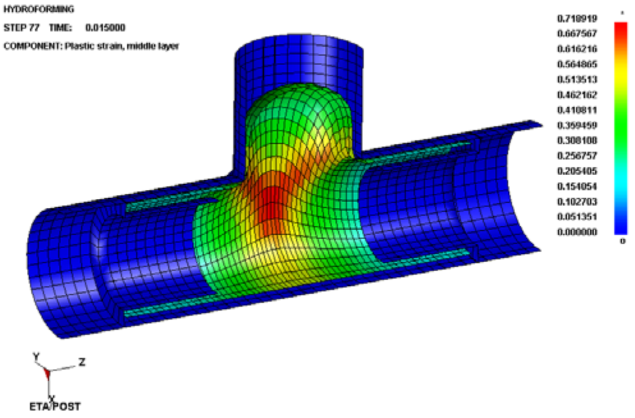
ZX Stress



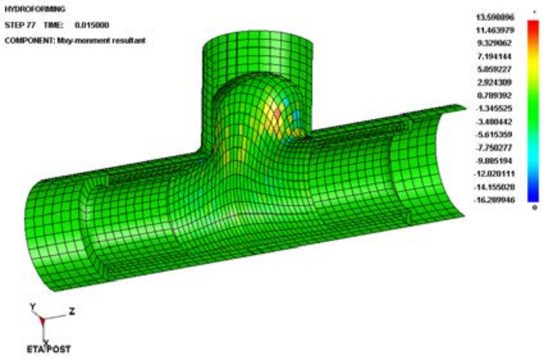
My Moment Result



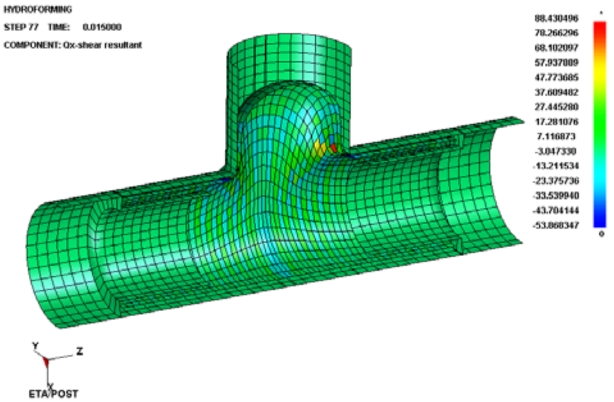
Plastic Strain



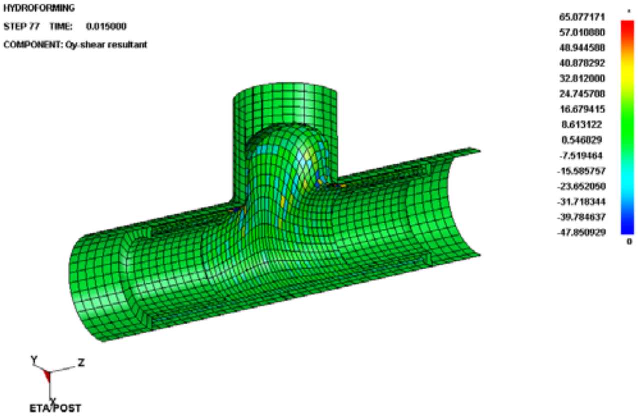
Mxy Moment Result



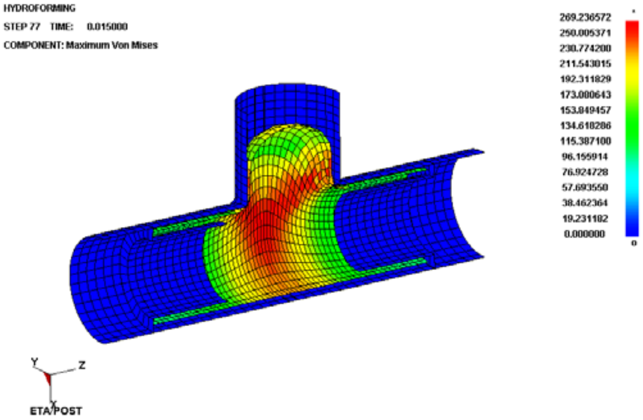
Shear X



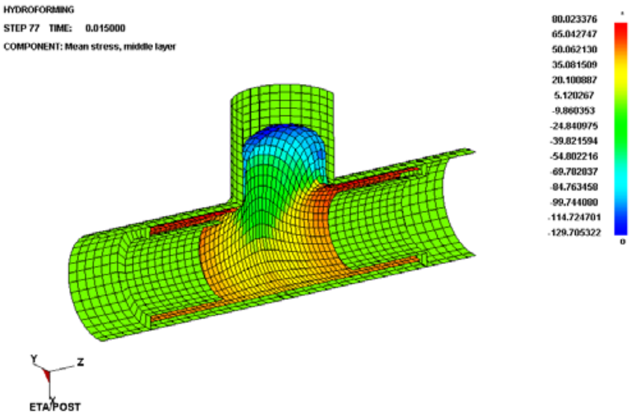
Shear Y



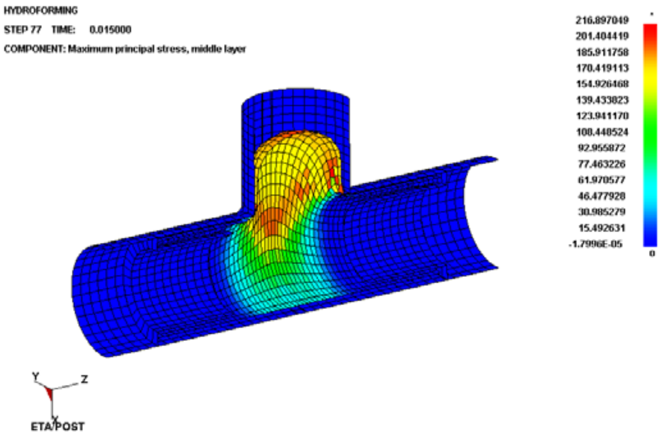
VonMises



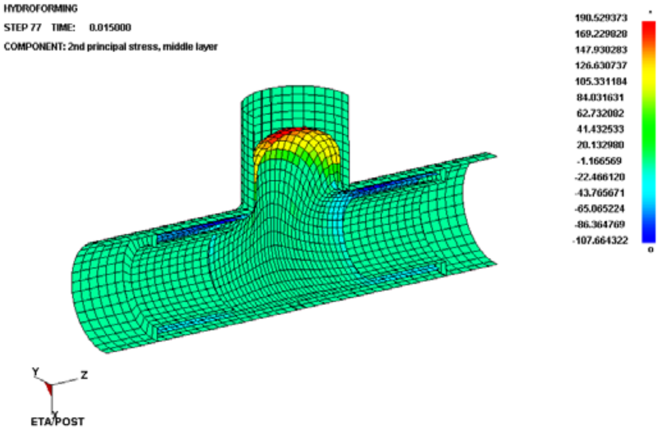
Mean Stress



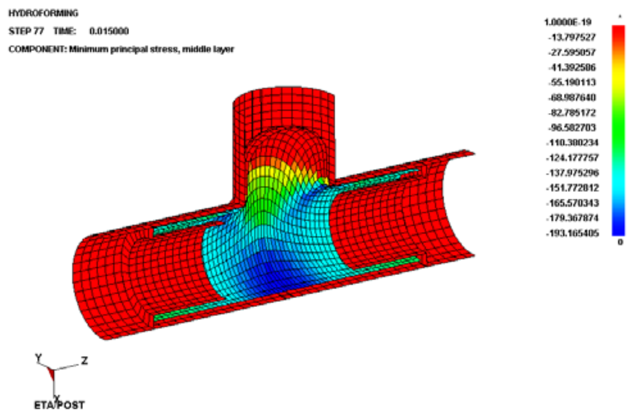
Max. Principal Stress



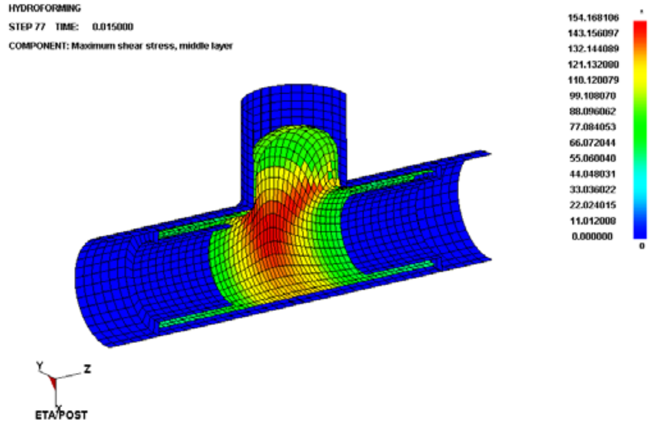
2nd Principal Stress



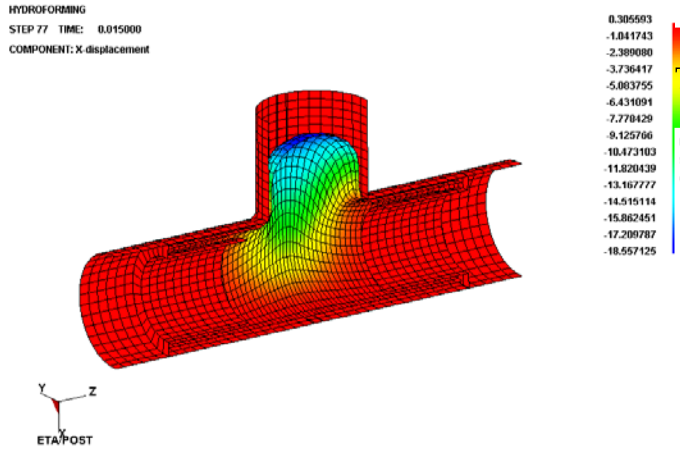
Min. Principal Stress



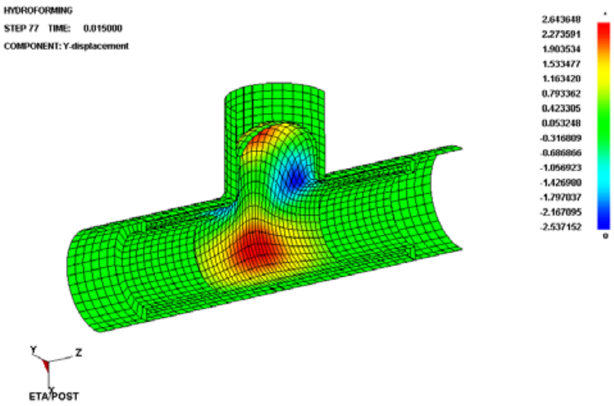
Max. Shear Stress



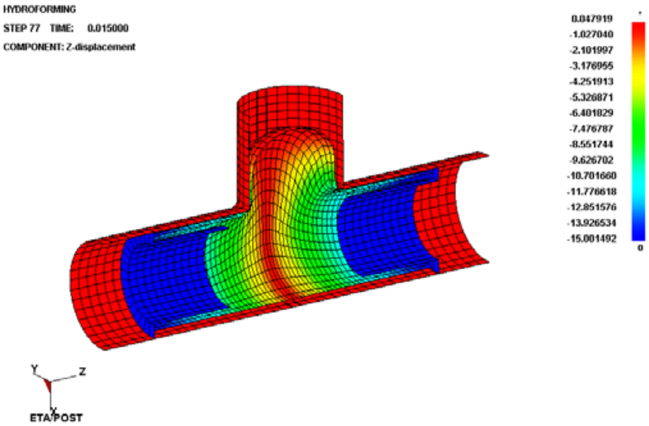
Displacement – X



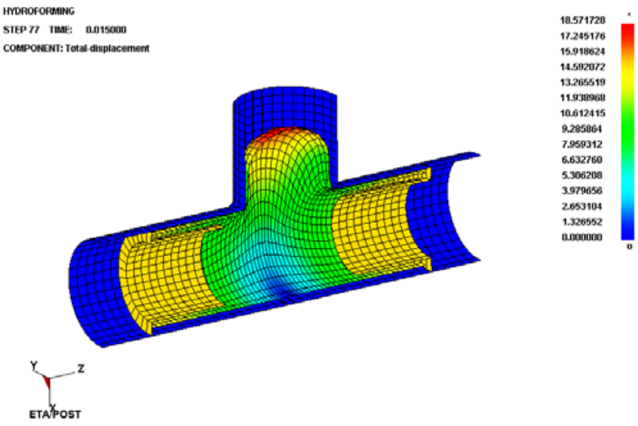
Displacement – Y



Displacement – Z



Total Displacement



CONCLUSION & FURTHER PROCESS REVIEW

The simulation of the tube hydroforming process conducted successfully through LS-Dyna. Based on the requirements and input details given by the company, this simulation is carried out for AA6082-T4. The simulation outputs valuable results like forming pressure, punch stroke level which is important for the manufacturing process. The results were verified by the technical committee of the SimTech Company and taken as base for the further research and datum for tube-hydroforming process.

This simulation further expanded to similar type of materials and different variety of same aluminum alloy to conduct a variation-analysis for finding the behaviour and manufacturability with specific reference to tube-hydroforming process.

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