Metal Hydro forming Research

Hydroforming: is a cost-effective way of shaping ductile metals such as aluminum, brass, low alloy steel, and stainless steel into lightweight, structurally stiff and strong pieces.

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Eng. Ihsan Mohammed Hussein

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Index

Hydroforming

The reason for choosing this research is that This technology is not yet known in Iraq.

<u>introduction :</u>

Hydroforming : is a cost-effective way of shaping ductile metals such as aluminum, brass, low alloy steel, and stainless steel 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 unibody 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.

Hydroforming is a specialized type of die forming that uses a high pressure hydraulic fluid to press room temperature working material into a die Increasing the water pressure — up to 100,000 pounds per square inch (PSI) — causes the tube wall to conform to the shape of the cavity formed by the mating die halves . To hydroform aluminum into a vehicle's frame rail, a hollow tube of aluminum is placed inside a negative mold that has the shape of the desired result. High pressure hydraulic pumps then inject fluid at very high pressure inside the aluminum tube which causes it to expand until it matches the mold. The hydroformed aluminum is then removed from the mold. Hydroforming allows complex shapes with concavities to be formed, which would be difficult or impossible with standard solid die stamping. Hydroformed parts can often be made with a higher stiffness-to-weight ratio and at a lower per unit cost than traditional stamped or stamped and welded parts. Virtually all metals capable of cold forming can be hydroformed, including aluminum, brass, carbon and stainless steel, copper, and high strength alloys.[1]

<u>Examples of the products types</u> :

Notable examples include:

SHF Sheet Hydroforming

1. Satellite antennas up to 6 meters in diameter.

2. Lighting fixture housing and reflector

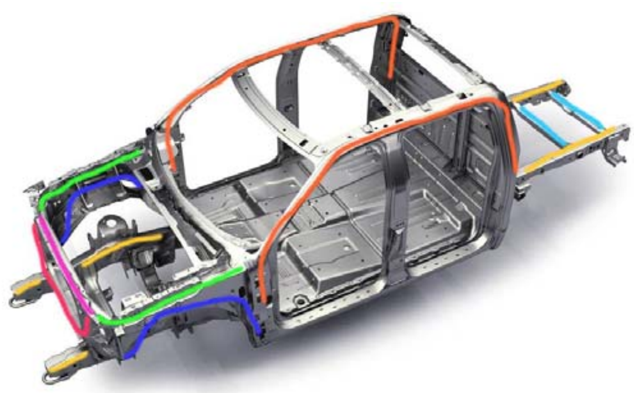
Copper float made by hydroforming 0.7 mm thick - 50 mm diameter X 100 height.

1.5 mm thickness - 100 mm diameter X 120 mm tall. Pump cylinder housing. Hydroforming is the main process.

THF Tube Hydroform

1. The brass tube of saxophones.

2. The process has become popular for the manufacture of aluminium bicycle frames. The earliest commercially manufactured one being that of the Giant Manufacturing Revive bicycle first marketed in 2003.



Engine base frames

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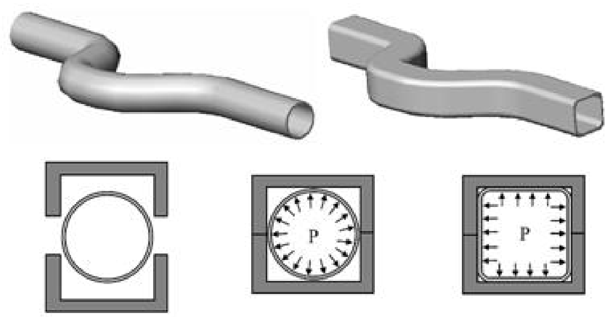
bicycle frame



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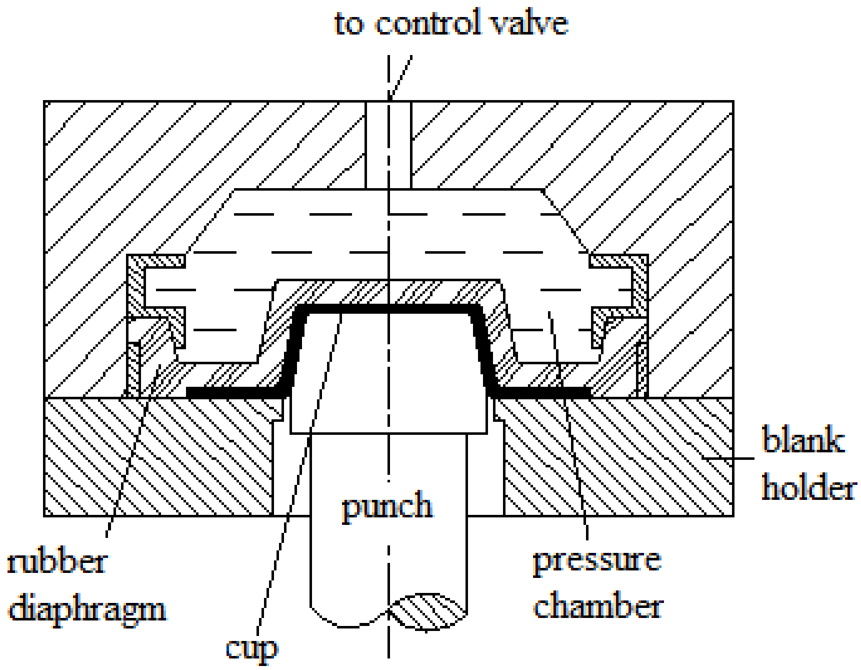
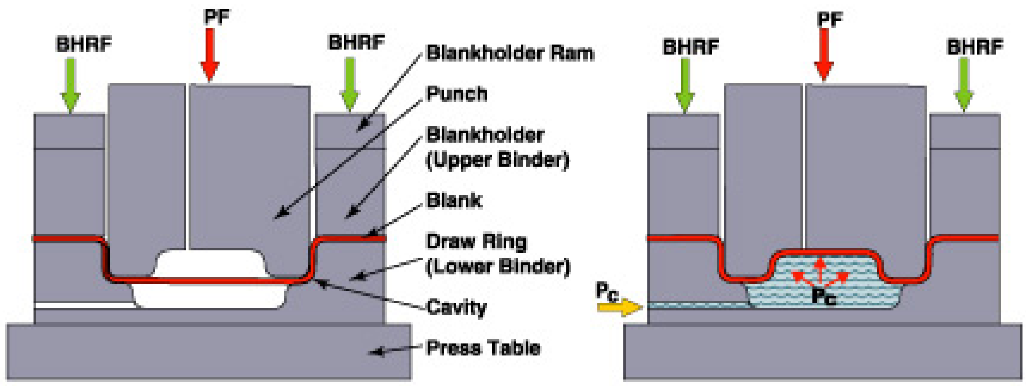
3. Many motor vehicles have major components manufactured using this technology, for example:
   - The technique is widely used in the manufacture of engine cradles. The first mass-produced one was for the Ford Contour and Mystique in 1994. Others from a long list include the Pontiac Aztek, the Honda Accord and the perimeter frame around the Harley Davidson V-Rod motorcycle's engine.
   - As well as engine cradles, the main automotive applications for hydroforming are suspension, radiator supports and instrument-panel support beams. The 1994 Buick Regal and Oldsmobile Cutlass had hydro-formed instrument panel beams. [16] The first mass-produced automotive component was in 1990 with the instrument panel support beam for the Chrysler minivan.
   - Various vehicle bodies and body components, the earliest mass-produced one being the 1997 Chevrolet Corvette. A selection from many examples are the current versions of the three major United States pickup trucks—the Ford F-150, Chevrolet Silverado, and Ram—which all have hydroformed frame rails, 2006 Pontiac Solstice[and the steel frame inside the John Deere HPX Gator Utility Vehicle.

Main process variants :

1. Sheet hydroforming :

the total pressure in the hydroforming zone is from 600 to 1000 p. s. i.





This process is based on the 1950s patent for hydramolding by Fred Leuthesser, Jr. and John Fox of the Schaible Company of Cincinnati, Ohio in the United States. It was originally used in producing kitchen spouts. This was done because in addition to the strengthening of the metal, hydromolding also produced less "grainy" parts, allowing for easier metal finishing.[3] In sheet hydroforming (SHF) 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 flexforming.[4] Flexforming is mostly used for low volume productions, as in the aerospace field.[5] 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[6]) 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.

Alternative names, other variants and similar processes;

- Hydromec (Hydromechanical deep drawing)
- Bulge forming
- Explosive forming
    - 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 pressuring medium. Particularly when the explosives are close to the workpiece, inertia effects make the result more complicated than forming by hydrostatic pressure alone.
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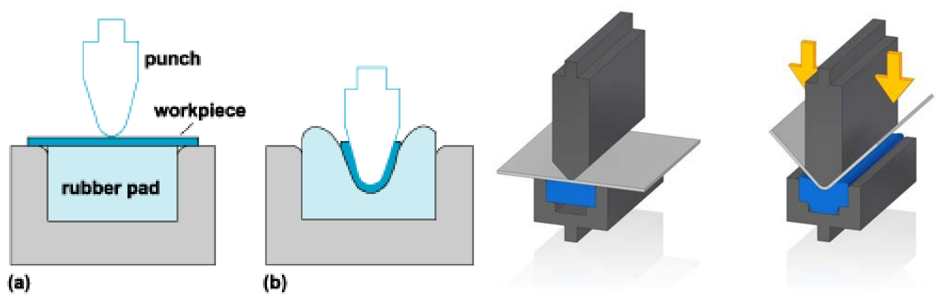
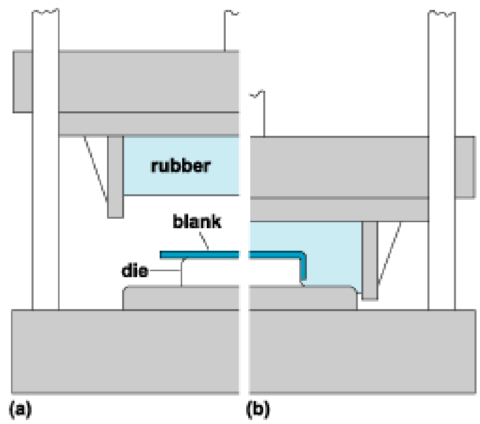
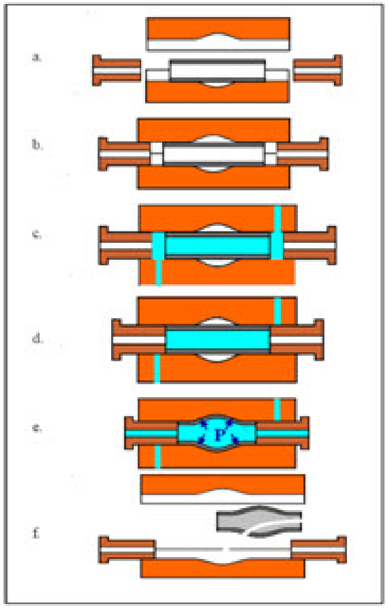
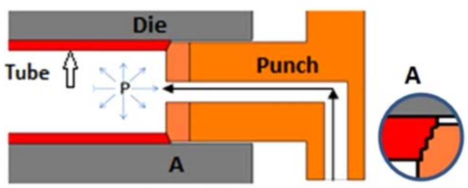
- **Rubber pad hydroforming**



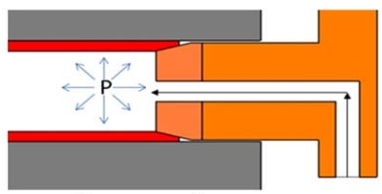


Tube hydroforming Technology :

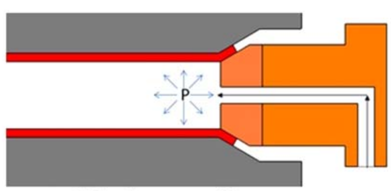




Stepped sealing system



Cone sealing system



Wedge sealing system

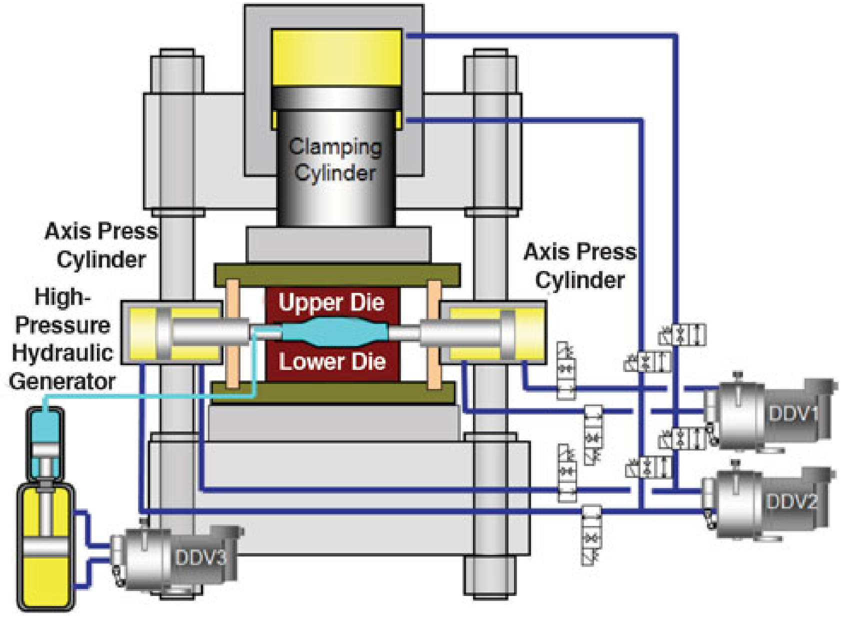
 

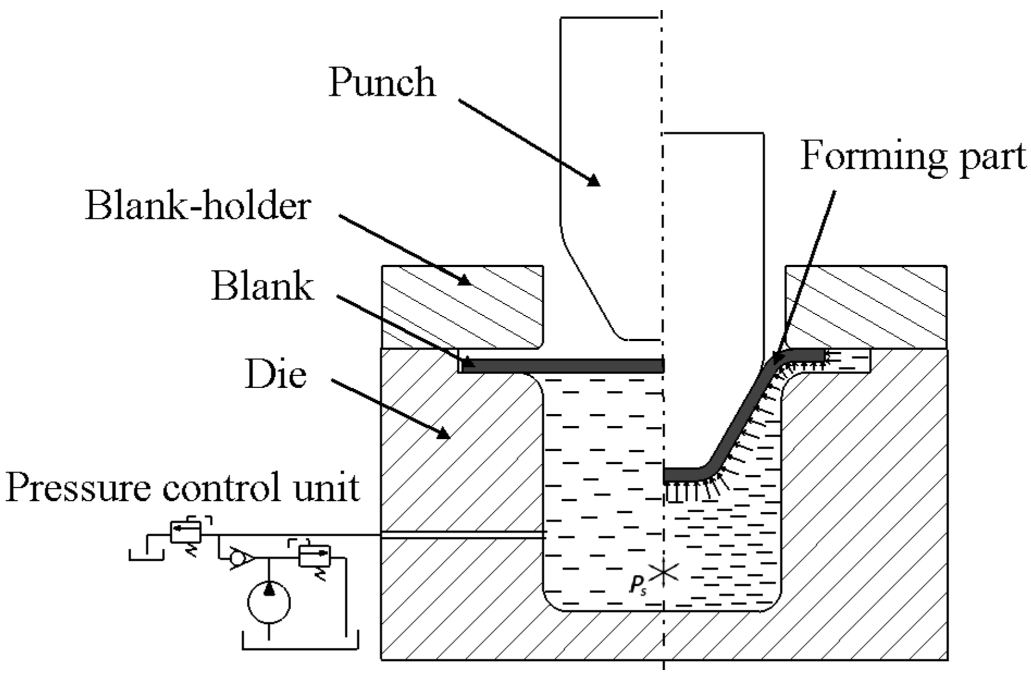
In tube hydroforming (THF) there are two major practices: high pressure and low pressure. With the high pressure process the tube is fully enclosed in a die prior to pressurization of the tube. In low pressure the tube is slightly pressurized to a fixed volume during the closing of the die (this used to be called the Variform process). Historically, the process was patented in the '50s, 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 thousand 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 modeling is possible only for very simple 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.

Typical tools :

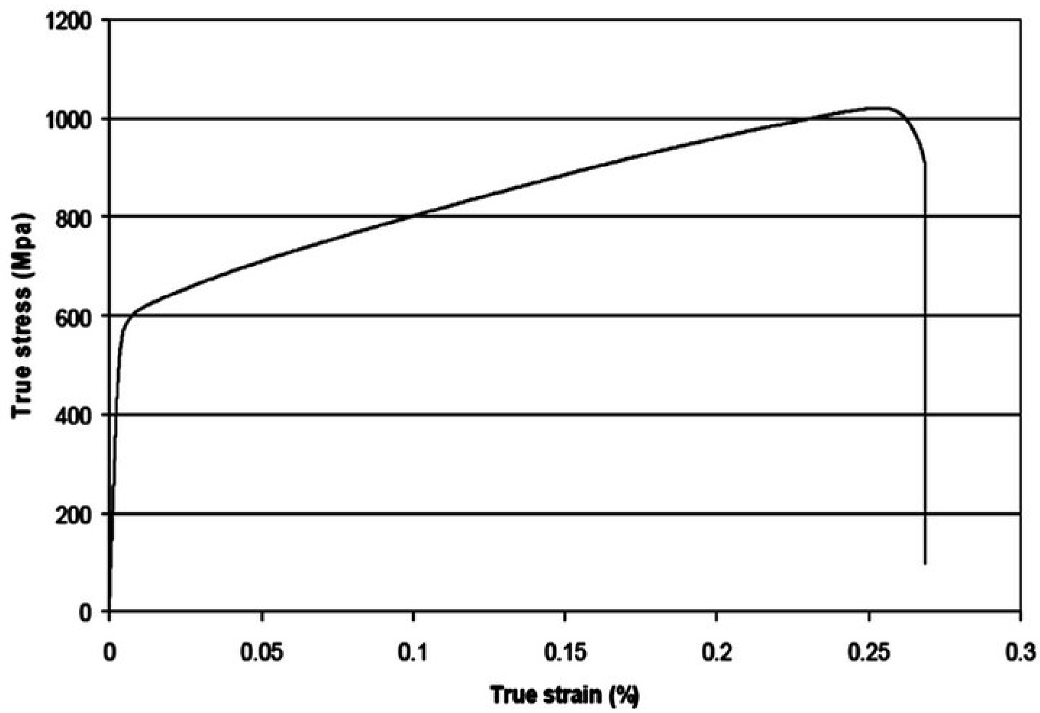




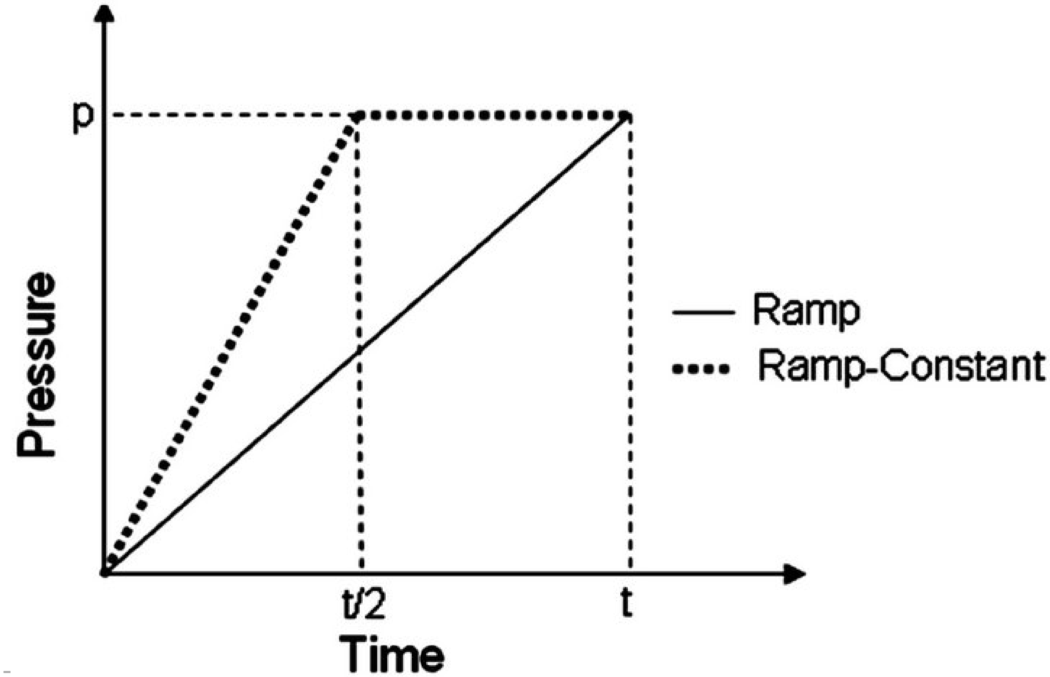
Tools and punches can be interchanged for different part requirements. One advantage of hydroforming is the savings on tools. For sheet metal only a draw ring and punch (metalworking) or male die is required. Depending on the part being formed, the punch can be made from epoxy, rather than metal. The bladder of the hydroform itself acts as the female die eliminating the need to fabricate it. This allows for changes in material thickness to be made with usually no necessary changes to the tool. However, dies must be highly polished and in tube hydroforming a two-piece die is required to allow opening and closing.

Geometry produced :

Another advantage of hydroforming is that complex shapes can be made in one step. In sheet hydroforming (SHF) with the bladder acting as the male die almost limitless geometries can be produced. However, the process is limited by the very high closing force required in order to seal the dies, especially for large panels and thick hard materials. Small concave corner radii are difficult to be completely calibrated, i.e. filled, because too large a pressure would be required. in fact, the die closing force can be very high, both in tube and sheet hydroforming and may easily overcome the maximum tonnage of the forming press. In order to keep the die closing force under prescribed limits, the maximum internal fluid pressure must be limited. This reduces the calibration abilities of the process, i.e. it reduces the possibility of forming parts with small concave radii. Limits of the SHF process are due to risks of excessive thinning, fracture, wrinkling and are strictly related to the material formability and to a proper selection of process parameters (e.g. hydraulic pressure vs. time curve). Tube hydroforming (THF) can produce many geometric options as well, reducing the need for tube welding operations. Similar limitations and risks can be listed as in SHF; however, the maximum closing force is seldom a limiting factor in THF.



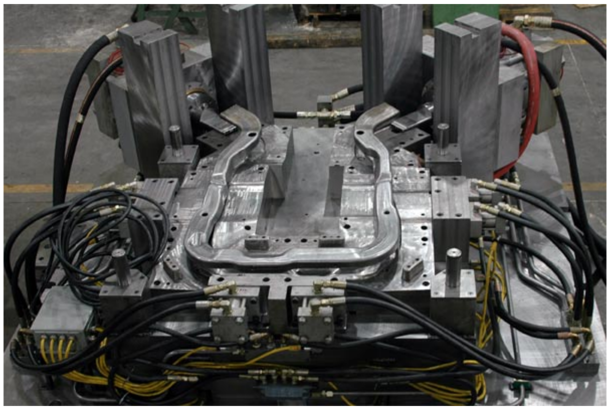
True stress-strain curve determined in tensile tests for TRIP steel.



Ramp and Ramp-Constant pressure curves for low pressure tube hydroforming.

Tolerances and surface finish :

Hydroforming is capable of producing parts within tight tolerances including aircraft tolerances where a common tolerance for sheet metal parts is within 0.76 mm (1/30th of an inch). Then metal hydroforming also allows for a smoother finish as drawmarks produced by the traditional method of pressing a male and female die together are eliminated.



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