

Sheet Metal Hydroforming

Process, variants, hydroforming vs deep drawing and stamping, equipment and design rules

Key Terms

Sheet hydroforming	Also called fluid forming. Pressurized fluid (water or oil) pushes a flat sheet against a single-sided die instead of a matched punch and die.
Tube hydroforming	A sealed hollow tube is expanded by internal fluid pressure until it fills the die cavity.
Bladder hydroforming	A flexible rubber diaphragm transmits the fluid pressure to the blank.
Pressure sequence	Pressure applied to different sections step by step (multiple chambers/ports or partial die closure) to even out material flow and reduce wrinkles and thinning.

Hydroforming vs Stamping

Factor	Sheet hydroforming	Stamping
Tooling	Single die + fluid system (lower cost)	Matched punch and die (higher cost)
Cycle time	Tens of seconds per part	1-1.5 s (40-60 strokes/min), ~20-50× faster
Part complexity	Complex, asymmetric, sculpted; undercuts	Simple 2D-3D geometry, shallow draws
Material use	Maximized, minimal trimming	More scrap from blanking
Best-fit volume	Low volume and prototypes	Very high volume (lowest cost/part at scale)

Hydroforming vs Deep Drawing

	Deep drawing	Hydroforming
Force applied by	External punch and die	Internal fluid pressure
Variables	Punch force is the only dependent variable	Pressure in the dome holds cup walls against the punch
Shapes	Cylindrical or box-like, constant depth	Deeper, irregular or asymmetric
Run rate	Better for higher volume	Better for lower volume

Equipment & Numbers

≤ ~10,000 psi

Fluid cell press: shallow parts, single unmated tool

10-20k psi

Deep draw press with upward-moving punch

120-2,000+ t

Deep draw press punch force range

3 : 1

Depth-to-diameter forming ratio on some parts

Tube Hydroforming Steps

- **1. Prepare:** cut to length, deburr, clean (steel or aluminum tube).
- **2. Bend & seal:** pre-bend to near-final shape, load in die, seal ends with clamps or plugs.
- **3. Pressurize:** inject fluid to expand the tube into the cavity; drain and remove; machine as needed.

Design Rules & Trade-offs

- Consider thickness, ductility and springback when selecting material.
- Sharp corners, deep draws and complex features may need extra tooling or process changes.
- Die design: cavity shape plus vent and port placement for fluid flow.
- Simulate before cutting tooling, then prototype and test.
- **Aluminum:** even pressure offsets lower ductility and springback; allows thinner gauges for lightweighting.
- **Pros:** tight tolerances, smooth surfaces, one-piece parts, fewer welds, thinner material.
- **Cons:** part size limits, specialized equipment and training, repeatability takes care.
- **Uses:** frame rails, engine cradles, exhaust, radiator supports, I/P supports, fuselage panels.