Metal Spinning and Hydroforming – The Stamping Alternative

Helander Metal Spinning Company

An ISO 9001:2008 & AS9100 Rev C. Registered Company

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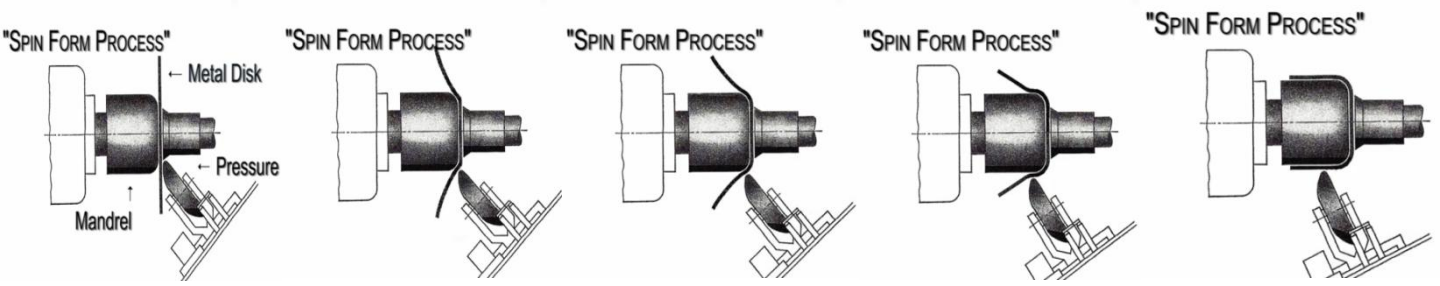
Introduction

Metal spinning and metal hydroforming are two manufacturing techniques that are ideal for the production of prototype, low or high volume quantities of light weight, and structurally superior, yet low cost parts. They both share the attributes of:

- low cost tooling,
- short lead times,
- fast cycle times,
- improved metallurgy, and
- minimal finish requirements.

Each is suited to a particular type of part geometry, and should be explored as alternatives to other fabrication processes.

Metal Spinning Basics



Metal Spinning is a process by which a disc or tube of ductile metal is rotated on a spindle and formed into an axially symmetric part.

It is a technology that mankind has used since ancient times — there is evidence that early Egyptians used hand-operated bows and poles to spin metal into bowls and other circular hollow artifacts. By the Middle Ages, a simple lathe-type machine was developed that allowed operators to continuously rotate spindles by means of a foot pedal, freeing their hands to control the speed of rotation and focus on accuracy. With the Industrial Revolution came the use of electric motors, which greatly increased the spinning speed, further improving accuracy and significantly boosting production volumes.

Today, modern metal spinning is conducted on rigidly constructed lathes that incorporate high velocity spindles and are operated either manually or through use of hydraulics or advanced computer controls. The spinning technique, however, has remained fundamentally the same.

By applying a levered force uniformly to a rotating disc of metal using rollers that spin at a very high speed, the metal begins to “flow” over a mandrel that is shaped to the interior geometry of the part or desired object. The rotational motion and forces applied, cause the metal to deform evenly without any wrinkling or warping to create a smooth, even, and seamless surface. The heavy forces also realign and strengthen the grain structure and significantly increase the tensile properties and fatigue resistance of the base material.

Types of Metals for Spinning

Almost any ductile metal can be formed, including aluminum, stainless and carbon steels, as well as high-performance alloys. Intricate curves, tight grooves, and other precise features of varying complexity can be executed in a single machining cycle.

Metal spinning lathes have the same basic characteristics as conventional turning centers, and indexable toolholders allow secondary turning operations and edge detailing to be performed in easy, rapid succession, with no need for the operator to perform setup tasks in between.

Metal spinning can be executed using various formation strategies, and the process applied is matched to the material of construction and required production volume. In manual spinning, a highly skilled operator carefully pulls a roller to hand shape the metal, and it is the ideal process for lighter gauge materials and prototype to low volume projects. Hydraulic assisted spinning offers the benefits and versatility of hand spinning when greater pressures are required for stronger metals and heavier gauge materials.

Adding advanced technology CNC controls brings higher levels of speed, precision, and consistency to the metal spinning process. Complex geometries with tight tolerance requirements can be achieved rapidly, accurately, and repeatably in medium to high production quantities.

In addition to programming this equipment utilizing modern computer assisted machining (CAM) software, operators can employ a “teach” mode, where the first piece is manually spun while the computer records the movements. Once the initial workpiece is formed, playback mode exactly duplicates the movements of the manual spinning operation, enabling automatic production of a large volume of components.

Hot Spinning

Although typically a cold working process, a “hot spinning" technique is commonly used to fabricate scuba tanks, fire extinguishers, and other pressurized vessels. Commonly referred to as “necking in”, metal tubing is heated up to 2000°F, and strategic forces are applied to concentrically reduce the tube diameter, form a shoulder, and close the tube ends, resulting in a seamlessly constructed cylinder with outstanding structural integrity.

Tooling for Metal Spinning

Tooling requirements for metal spinning are simple and include only a mandrel and roller spinning tool. Since mandrels are not subject to excessive forces, low-cost hardwood materials are often sufficient for prototype, low volume, or soft material applications.

For projects that involve more difficult-to-form alloys, require execution of longer production runs, or have critical tolerance requirements, metal mandrels are preferred. However, since quality mandrels can be produced by simple turning and machining, both lead times and expense are minimal.

The simplicity of the tooling requirements for metal spun products allows forming parameters and part geometry to be altered quickly by using tool offsets and graphical manipulation, allowing design changes to be easily accommodated with minimal to no expense.

Metallurgically, when the spinning roller contacts the workpiece, the highly localized pressure that deforms and cold-works the metal compresses the grain structure and hardens the material. Tensile strength is improved, allowing lighter gauge material with thinner-walled construction to exhibit the same performance parameters as stamped or machined equivalent.

In addition to utilizing less material, increased material yield contributes substantially towards the economy of a spun metal part. Careful calculations enable right-sized blanks to be formed into their final shape with little to no material waste.

Part Diameter and Depth from Metal Spinning

The diameter and depth of spun metal parts are limited only by the capacity of the equipment available, and metal spinning offers one of the largest and most dynamic work envelopes of any fabrication process.

Using basic equipment all the way up to high horsepower spinforming lathes, components with outer diameters measuring as small as one-inch to as large as 8-feet are easily formed, and part depths of up to 3-feet can be readily accommodated. Sidewalls measuring up to ½-inch in thickness provide outstanding structural integrity for components with the largest of dimensions.

For axially symmetric parts, metal spinning is an efficient and cost-effective production method. For parts that have intricate features or are irregular in shape, metal hydroforming, also known as fluid forming or rubber diaphragm forming, is offered as another fabrication technique for shaping ductile metals into lightweight, high strength parts.

Developed in the late 1940's and early 1950's in response to a need for a low cost method of fabricating relatively small quantities of deep drawn parts, it is a technically elegant alternative that utilizes the principles of fluid dynamics to produce a seamless part that is extremely lightweight, strong, and durable.

Metal Hydroforming Basics

Metal sheet hydroforming is an economical solution for manufacturing parts with complex or asymmetrical geometries that would require multiple punch cycles in a matched die stamping process. The sheet hydroforming technique replaces one of the rigid dies used in conventional stamping with highly pressurized hydraulic fluid, contained by a urethane diaphragm, to force the sheet metal into a one-sided die cavity.

Since the urethane bladder, which is essentially acting as the female die, has no distinct shape, its dynamics allow it to take on the shape of any conceivable geometry. This allows complicated shapes with concavities to be formed, which would be difficult or impossible with standard solid die stamping. The ability to form difficult shapes and irregular features in a single press cycle results in fewer forming operations compared to conventional stamping. Produced to net shape, a single hydroformed component can often replace multiple parts, resulting in assemblies with fewer parts, higher strength, and less cost.

Another advantage of sheet hydroforming is that the uniformly applied pressure distribution during forming creates less friction than deep draw stamping, thus reducing stretching and strain on the material. This allows for increased drawability and results in more consistent, even wall thickness. Less strain on the material results in parts with greater structural integrity, which allows creation of lighter weight and thinner parts that exhibit the same performance parameters as a stamped alternative, which saves on material usage and reduces manufacturing costs. Also, because of the decreased friction and absence of rigid tool contact, sheet hydroforming creates blemish-free formed parts with smooth surface finishes that don't require the added expense of buffing, polishing, or other finishing processes. Because of this advantage, sheet hydroforming is often the technique of choice for producing medical and aerospace applications that require superior surface finishes.

Type of Metals for Hydroforming

Virtually all metals capable of cold forming can be hydroformed, including aluminum, nickel, carbon, stainless steel, and copper, as well as high strength, high temperature alloys. It offers a large and dynamic work envelope that allows for the production of structurally strong components with dimensions of 1.0” to 30.0” in diameter and draw depths of up to 12.0”. Tight, aircraft standard tolerances of ±.003” are easily achieved.

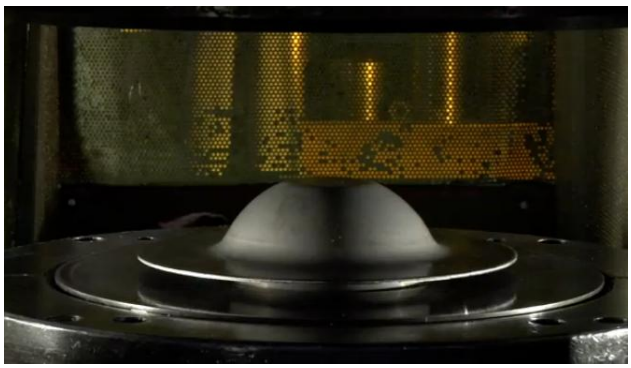
Steel

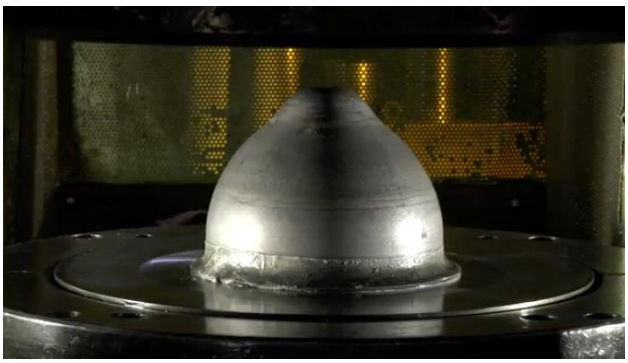
Brass

Aluminum

Copper

Tooling for Metal Hydroforming





The tooling for sheet hydroforming consists of male die and a draw ring (blank holder). The urethane rubber diaphragm in the hydroforming press acts as a universal female die, eliminating the need to fabricate it.

The dynamics of the process also allows for changes in material thickness to be made without requiring changes to the tool, and less complicated tooling also allows for shorter lead times. Hydroform tools normally cost at least 50% less, if not up to 80%-90% less than conventional press tooling.

Advantages of Metal Spinning and Metal Hydroforming

Both metal spinning and sheet hydroforming offer great potential for prototyping and low and medium volume production, which is a current manufacturing trend for products with unique customizations, intrinsically low demand, or a short lifecycle because of changes in consumer preferences.

Economical, low volume production also gives business the ability to enter new markets or find a specialized niche in an established market. Producing at low volume at a lower investment reduces a company's risk and exposure while giving them the ability to test growth and expansion opportunities and explore product development strategies in less familiar markets.

Metal spinning and hydroforming are both very versatile, and have uses in many industrial, medical, commercial, transportation, and architectural applications. Capable of meeting an almost infinite array of design challenges, both can be applied to improve and add flexibility to the manufacture of a diverse range of components.






Advantages of Metal Spinning and Metal Hydroforming *(continued)*

Take for example the automotive industry, where there is great interest in utilizing lighter weight components to meet fuel reduction targets and reduce CO2 emissions. The increase in demand for maximum fuel efficiency along with higher safety and environmental standards are forcing automotive manufactures to utilize strong lightweight materials, such as aluminum, as well as new manufacturing techniques to reduce vehicle weight. Spun metal or hydroformed components allow engineers to specify lighter weight parts that exhibit increased strength and resistance to environmental exposures over machined or stamped alternatives.

In the architectural industry, both of these manufacturing techniques are used for projects of varying scope and complexity. Cylindrical lighting components can be produced en masse for commercial applications, while low volume production is an ideal way for designers to add unique and dramatic lighting to a commercial application at reasonable expense. Standard items, such as door handles, can be given a distinctive flair while maintaining strict wear and functional requirements.

Technologically complex equipment, such as systems used in the medical industry, is typically manufactured in low volume quantities, making spin and hydroforming an ideal choice for just-in-time delivery of only several units per order. The expense of long-term part inventory is avoided, and ongoing design changes due to technological advances are easily accommodated at minimal expense.

Summary

Metal spinning and hydroforming have become competitive metal forming methods and have succeeded in many applications because of their weight- and cost-saving attributes and favorable strength properties. Costs are reduced and time is saved by:

- eliminating secondary operations,
- reducing scrap, lowering material costs, and
- increasing design flexibility.

While the examples above demonstrate their benefits to only three industries, components formed using these techniques enjoy widespread use in a diverse range of industries, from aerospace and defense to transportation and everything in between.

Helander's engineers, manufacturing technologists, and material specialists can provide in-depth analysis of component design and advise you on the feasibility and practicality of using metal spinning or hydroforming to form your component part. Contact us today to let us help you decide.

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Helander Metal Spinning

For over 70 years, Helander has been a major partner to a variety of Fortune 500 companies and small businesses, providing them with metal forming and fabricating services.

Our long history of production excellence has been built by continually adhering to our customer's rigid specifications. Quality is and has always been our emphasis. In fact, we are ISO 9001:2008 certified since November 1999 and recently became AS9001 Rev. C certified as well.

Our niche is forming cylindrically shaped parts ranging from 1.00" diameter to 72" in all types of metals and production quantities. Helander's Core Business Competencies are Metal Spinning and Sheet Hydroforming (Deep Drawing).

Helander Metal Spinning Company's 30,000 square foot state of the art facility built in 1994 is located in Lombard, Illinois, approximately 20 miles west of downtown Chicago.

We work with the aerospace industry, high-end furniture manufacturers, Tier 2 and 3 automotive companies, the medical sector, and agricultural industries. Our emphasis is on providing our commercial, aerospace and defense customers with superior service, no matter the industry. We focus our efforts on customer service, prompt deliveries, and efficient performance.

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Resources

Sheet Hydroforming is the Part-Forming Solution for Smaller .., http://www.jmpforming.com/techtalk/hydroforming/sheet-hydroforming-ts-the-part-forming-solution-for-smaller-press-runs.htm (accessed September 9, 2013).

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