Hand Spinning and CNC Spinning

Metal Spinning, a Bridge Between Craft and Automation

Metal Spinning is a metalworking process that stands firmly between the artisans and craftsmen of the past and the machine tool automation of the present and future. It is a process certain to benefit from the high volume manufacturing techniques being developed, while still demanding high levels of individual craftsmanship. Manufacturers choosing to work in metal spinning will tap into the high production capabilities of an automated shop floor, but also require manual spinning to create more intricate architectural and decorative products. Combining both of these techniques allows for the mass production of the bulk of a product line through CNC automation, while finishing it up with hand spinning creating a product that is hand-worked.

Metal Spinning Technology: A Closer Look

On the surface, the spinning process is a simple one. A formed block, or mandrel, is mounted in the center drive section of a lathe. This formed block is the part that defines the shape of the final product. The block is machined from a variety of materials, including wood, polyurethane, aluminum and steel, each having its own strengths and weaknesses. A pre-sized metal disk, called the work piece, is then clamped against the 'front' of the block by a pressure pad. This pressure pad is also attached to the tailstock of the lathe. The block and the attached work piece are then rotated at high speeds. While rotating, a localized force is applied to the work piece. This force causes the work piece material to bend over the block. The force is usually applied by levered tools called 'spoons.' The process is completed when the work piece is fully formed around the block - taking its shape. The final diameter of the work piece is always less than the starting diameter of the metal disk, so the work piece must thicken, elongate radially, or buckle circumferentially during the process. Once complete, simple work pieces can be removed from the block and another metal disk can be clamped into place. However, more complex shapes may require multi-piece blocks to be separated and removed.

In order to create shapes that include thinning necks or reentrant geometries, a process known as reducing, or necking, can be used. If the surface finish and final form are not critical to the final part, then the work piece can be 'necked' by being 'spun on air' with no block. If the surface finish and final form are critical then an eccentrically mounted block can be used instead. Other parts can be formed by using the previously mentioned multi-part, separating, and mandrels. Extremely complex shapes and one-offs can be spun on ice-molds, or other low melting point materials. Once the part is complete, the system is heated and the block melts away so the part can be removed. Another process, "hot spinning," involves spinning a piece of metal on a lathe while applying high heat from a torch. Once heated, the metal can be shaped as the tool presses against the more malleable surface forcing it to distort as it spins. Parts can then be shaped or necked down to smaller diameters with less force being required. This process can provide tighter seamless shoulders with respect to other spinning processes.

931 N. Ridge Avenue, Lombard, IL 60148
Phone: 630.268.9292 • Fax: 630.268.9393
sales@helandermetal.com • www. helandermetal.com

Metal Spinning Technology: A Closer Look (cont.)

All of these processes can be executed by hand spinning or on fully automated systems. Hand spinning is the most cost effective and reliable way to produce prototypes, small quantity orders, to shape semi-precious or precious materials, and to work with highly pliable, ductile, metals such as O-tempered aluminum and some lighter gage and stainless steels. Whereas CNC spinning is used for high quantity production where consistency is a necessity and runs of less malleable, and more difficult to spin materials, where a mechanized motive power is required.

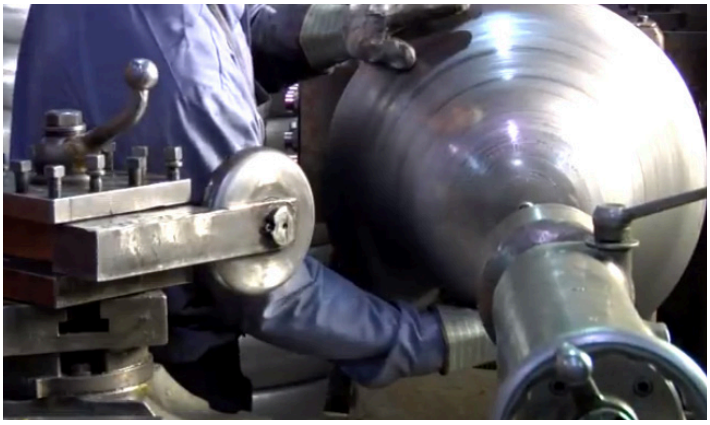
Hand Spinning

During hand spinning, the operator controls both the spinning speed and forming forces. Hand spinning is a craft where the operator subtly works with the material to create a form. This is done through precise motions rather than brute force. A form is created by an operator who can feel the structure of the metal, its grain, its hardness, and its willingness to move in one direction or another. With one hand, the operator uses the spoon to shape the work piece over the block, while the other hand applies the necessary lubricants or additional pressure to assist the process. There are an infinite number of tool designs that can be forged in steel to assist in spinning a variety of shapes. The length of the tool handle provides the leverage that works the piece down the mandrel. This handle can be mounted on tool posts and use tool guides to assist the operator. The tool post acts as a fulcrum for additional leverage or a 'third hand' assisting in tool placement. For forming, the tool that is most used is called a Sheep's Nose, while a Duck's Bill is used for finishing.

Many spinning shops will use tools with rollers mounted on long steel tube handles for forming and a peg-board mounted on the lathes cross feed to act as a rapid placement tool post. Even with the advantages of modern day tooling, hand spinners must always work with the material, instead of forcing it, allowing the operator to form a final product smoothly, quickly and evenly. During the forming process, it is vital to confirm that the material is fitting tightly and evenly over the block. This can be judged by the sound and feel of the metal, as the pressure of the spoon remains very steady. The material should be spun thin and smooth, similarly to the process of throwing and working with clay on a pottery wheel. A skilled operator can produce shapes that are precise to about 0.004 inches (0.100 mm).

931 N. Ridge Avenue, Lombard, IL 60148
Phone: 630.268.9292 • Fax: 630.268.9393
sales@helandermetal.com • www. helandermetal.com

Hand Spinning (cont.)



Hand spinning, used for both commercial and artistic manufacturing, is a disappearing but not dead art form in the age of deep draw metal stamping. However, it can be much more economical for smaller (<100,000) runs and yields more perfectly finished parts with no stretch marks or wrinkles. It uses an operator's intuitive sense of the material to take advantage of the intrinsic properties. There is a sense of quality in the process of hand spinning that makes it a true craft, meaning that its practitioners are genuine artisans.

In general, hand spinning works on most of the basic industrial metals and alloys. It works on iron, aluminum, stainless steel, copper, and brass. However, it has its best return for effort when working on precious metals like gold, silver, and platinum. Recently there is an increasing demand for work in a host of minor and refractory metals such as molybdenum, tantalum, and titanium. These materials are not normally thought of as proper candidates for spinning due to their hardness and brittleness, but with recent advances in hand spinning techniques they are now being successfully spun by hand.

The products created by hand spinning cover a wide range: prototypes of beverage cans, mechanical parts for satellites and aircraft, components for semiconductor manufacturing equipment, large parabolic antennas, and so on—many products of all different sizes. The use of hand spinning has many manufacturing and economic benefits. Following is a list of the most notable.

- It requires minimal effort for set-ups and, with the proper block material, several operations can be performed from a single set-up.
- A product can be completed and verified, and if determined necessary, the process can be optimized by simply modifying the spinner.
- Workpieces can be shaped that have re-entrant profiles and the design profile in relation to the center line is virtually unrestricted.
- If it is determined that a design change is required, the forming parameters can be immediately altered and new blocks can be quickly designed, all at little cost.
- The inherent level of repeatability allows for the inclusion of tight tolerances.
- The process has much lower tooling and production costs with respect to other forming technologies like deep draw metal stamping
- The ease of creating exact tooling, the minimal set-ups, and the ease of loading materials drastically shorten lead times.
- Hand metal spinning processes are extremely flexible and lend themselves to simple automation. They are equally applicable to the cost-effective production of small batches, one-offs and prototypes.
- One of the greatest cost reductions for hand spinning is in the reductions of waste in raw materials. This savings is most dramatic with respect to the use of precious metals. There is savings in the thickness of the material and their is practically zero net waste on the final product.

931 N. Ridge Avenue, Lombard, IL 60148
Phone: 630.268.9292 • Fax: 630.268.9393
sales@helandermetal.com • www. helandermetal.com

Hand Spinning (cont.)

In general, hand spinning works on most of the basic industrial metals and alloys. It works on iron, aluminum, stainless steel, copper, and brass. However, it has its best return for effort when working on precious metals like gold, silver, and platinum. Recently there is an increasing demand for work in a host of minor and refractory metals such as molybdenum, tantalum, and titanium. These materials are not normally thought of as proper candidates for spinning due to their hardness and brittleness, but with recent advances in hand spinning techniques they are now being successfully spun by hand.

The products created by hand spinning cover a wide range: prototypes of beverage cans, mechanical parts for satellites and aircraft, components for semiconductor manufacturing equipment, large parabolic antennas, and so on—many products of all different sizes.
The use of hand spinning has many manufacturing and economic benefits. Following is a list of the most notable.

- It requires minimal effort for set-ups and, with the proper block material, several operations can be performed from a single set-up.
- A product can be completed and verified, and if determined necessary, the process can be optimized by simply modifying the spinner.
- Workpieces can be shaped that have re-entrant profiles and the design profile in relation to the center line is virtually unrestricted.
- If it is determined that a design change is required, the forming parameters can be immediately altered and new blocks can be quickly designed, all at little cost.
- The inherent level of repeatability allows for the inclusion of tight tolerances.
- The process has much lower tooling and production costs with respect to other forming technologies like deep draw metal stamping
- The ease of creating exact tooling, the minimal set-ups, and the ease of loading materials drastically shorten lead times.
- Hand metal spinning processes are extremely flexible and lend themselves to simple automation. They are equally applicable to the cost-effective production of small batches, one-offs and prototypes.
- One of the greatest cost reductions for hand spinning is in the reductions of waste in raw materials. This savings is most dramatic with respect to the use of precious metals. There is savings in the thickness of the material and their is practically zero net waste on the final product.

931 N. Ridge Avenue, Lombard, IL 60148
Phone: 630.268.9292 • Fax: 630.268.9393
sales@helandermetal.com • www. helandermetal.com

Hand Spinning and CNC Spinning

	Hand Spinning	CNC Spinning
High Level of Individual Craftsmanship	X	
High Quantity		X
Use of machines to aid production		X
Bell-shaped, spherical, and tubular forms designed and created quickly	X	X
Most precise for part production		X
Spinning is effective for creating prototypes because rapidly part production	X	X
Produce minimum amount of wasted material	X	X
Faster process when compared to other machining methods such as stamping	X	X

Automated and CNC Spinning

Over time, various devices, such as scissors-levers or tool rests, were developed to assist the operator of a spinning machine. These tools were designed to increase the control and maximize the force that an operator could apply to the workpiece.

Spinning with the assistance of hydraulics, or other powered tooling is known as power or shear spinning. In this technique, metal is deformed using tools with extremely high shear forces (up to 3.5 Mega Newtons, or 800,000 pound-feet). There are two broad applications of power spinning. One application is metal cone spinning and the other is metal tube spinning. Almost all ductile metals (>2% ductility) can be shaped using power spinning. This process takes parts that used to cost thousands of dollars in tooling for a stamping, and produces them for several hundred dollars with spinning.

931 N. Ridge Avenue, Lombard, IL 60148
Phone: 630.268.9292 • Fax: 630.268.9393
sales@helandermetal.com • www. helandermetal.com

Automated and CNC Spinning (cont.)

There are several advantages of automatic spinning. One is that it removes the many uncertainties of operator skill and operator-to-operator variations, making spinning highly repeatable and accurate. After a CNC machine has been programmed or 'trained,' it can automatically execute the instructions, hydraulically applying predetermined forces for predetermined lengths of time on precise areas of the blank, creating fairly identical parts. Such machines can automatically shape the part, trim or otherwise finish the edges, and eject the finished part.

The first automatic lathes were very basic. They consisted of a single working lathe, or spindle, in which the workpiece was hand positioned on the block. Once positioned, a device was actuated to clamp the workpiece against the lathe for rotation. After the system was fully checked, the operator engaged the CNC controller and then stood by as the tool did its job. The operator monitored the system as the CNC interface performed the spinning process using slide-mounted tools. These machines have been arranged with template controls or other devices to control the movement of slide-mounted tools along two axes or by positioning the travel to match the straight taper when conical parts are being made. The operator then manually releases the workpiece, removing it from the lathe in order to insert the next workpiece. It is possible for one machine operator to operate several single automatic spinning machines, however, the cost of the equipment, the floor space required, and the machine handling equipment involved quickly becomes excessive. Also, these machine tools could only manufacture a single part at a time.

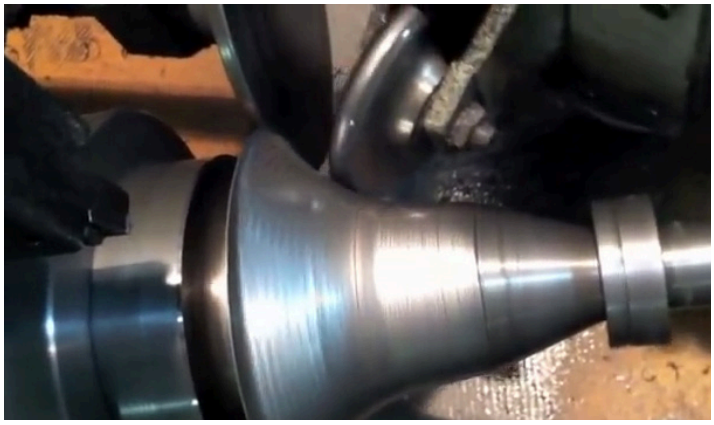
The operator of automatic spinning machines are able to program the lathe in a variety of ways. They can use a Computer Assisted Machining (CAM) package on a computer to 'draw' spinning passes on a diagram of the part, or they can plot coordinates into the specialized software, which will then generate the spinning passes necessary to make the part. The operator then runs the program to form a part, easily making adjustments to the program necessary to fine tune the part. Another CNC input process is called Programmable Numeric Conrol (PNC). In this system, a computer records the actual pathing motions of the operator as practiced on a set-up piece. The machine 'learns' this motion and then replicates it automatically on future parts.

The increased level of automation is one of the reasons that metal spinning has become even more economical on the shop floor. Though the metal spinning cycle can be relatively long, the level of automation in the latest equipment frees the operator to do other things while the machine tool is forming a part. With the equipment moving at a very rapid speed, the machine can apply the roller in several different ways, yielding multiple results. For instance, a stainless steel vase might require a number of grooves or decorative features—a designer can program the CNC roller to create each of these shapes in any given order, performing them within about 1/32" accuracy each time. A CNC spinning machine rarely requires retooling, which results in much tighter turnaround periods, but even if the project requires new tooling, workers can swiftly assemble new rollers. Since the machine tool now needs minimal monitoring, they can be surrounded by secondary equipment in a 'work center' approach, common among spinners to improve the cost effectiveness of spinning.

931 N. Ridge Avenue, Lombard, IL 60148
Phone: 630.268.9292 • Fax: 630.268.9393
sales@helandermetal.com • www. helandermetal.com

Automated and CNC Spinning (cont.)

There are several advantages to automatic spinning. One is that it removes the uncertainties of operator skill and operator-to-operator variations, making spinning highly repeatable and accurate. After a CNC machine has been programmed it will automatically execute these commands again and again, limited only by maintenance or the ability of the operator to continue to feed it blank materials. These programs can also be transfered from machine tool to machine tool, stored for future processing, and easily updated and refined for future parts runs. The use of highly skilled metal spinners is no longer necessary to run these machine tools. However, an operator must still be knowledgable about the intricacies of metal spinning as well as the control software required to run the part.



Manufacturers use CNC metal spinning to produce high volumes of lamps, spheres, vases, canisters, tubes, bottles and many other items. CNC metal spinning is also used for high dimensional precision and where repeatability is essential.

CNC metal spinning has many advantages over hand spinning and other technologies. Following is only a small sample of these advantages.

- CNC spinning is used where tight tolerances are required
- The work envelope of spinning lathes is highly consistent, so the programming of these complex machines allows for thousands of exact copies to be made from a single form
- A CNC spinner is not impacted by the nuances of different operators, their well-being, moods, or feelings
- A CNC metal spinner can be used continuously twenty four hours a day and seven days a week, and only need to be turned off for maintenance
- CNC spinners finish products faster than hand spinning
- CNC spinner have more reliable and consistent finishes
- Each part removed from a CNC spinner will be more or less identical to the previous or next part
- Running a CNC spinner has lower overall costs than hand spinning
- A CNC spinner has a very short lead time as jobs can be finished and switched over very quickly with the simple changing of a form and its program
- As with hand spinning, the up front tooling cost of metal spinning is very low compared to deep drawing or pressing

931 N. Ridge Avenue, Lombard, IL 60148
Phone: 630.268.9292 • Fax: 630.268.9393
sales@helandermetal.com • www. helandermetal.com

Advantage: Hand and CNC Combo-Spinning Shops

Even with all the recent advancements of CNC metal spinning machine tools, there is still an existing requirement for hand spinning techniques within a machine shop. The CNC technique is the most efficient, precise and rapid technology for forming metal. It is indeed often the most cost efficient due to its relatively low variable costs in producing items such that are bell shaped, spherical or tubular forms, However, it typically does not the finesse or feel for the material that a hand spinner must master.

A shop that uses both CNC metal spinning as well as employing those who are versatile in hand spinning has a great advantage over those shops that use only one technique or the other. Although CNC metal spinning is effective at producing products quickly, efficiently, and repeatably, manual metal spinning is still necessary for the development stages. In a pinch, it is also an effective method for producing short production runs in order to free up expensive CNC equipment for longer, more intricate production cycles. This ease of applying automation leads to faster lead times in producing short or long runs of a product. If a product does not require any specialized tooling, the turnaround can be as short as a few weeks. These faster lead times foster appeal for metal spinning as a quick and efficient production method for prototypes and one-offs.

While a CNC machines can mass produce high consumption consumer goods more efficiently than hand spinning there are still many products that require the work of a craftsman. People believe that, with the rapid rise of CNC and other automated spinning systems, that hand spinning is a dying art. However, there are still schools and shops throughout the United States, Japan and Europe that continue to train high class apprentices in the fine arts of metal spinning. Forming subtle curves and other features requires the skilled techniques of an artisan. There is a great advantage in knowing how slight variations in pressure or rotation will effect changes in form and finish. While sensing and feedback systems have greatly improved in recent years they still do not have the intuition of a master artisan. To change the angle and force of the tool with instantaneous judgment requires a ‘sixth sense,’ developed by many years of experience and apprenticeship. This kind of intuition is necessary when forming devices that are based not only upon a pre-programmed form, but one that must also fit more artistic criteria, such as aesthetic or tonal (such as vases, musical cymbals, and even some aerospace and high technology designs.)

When a machine shop excels in a variety of techniques, such as manual, CNC, automated, and shear or power spinning they can provide their customers the widest range of possibilities. The most efficient and fastest techniques can be chosen to manufacture prototypes, low volume, and high volume runs within a variety of customer specifications. (i.e. tight tolerances, repeatability, reductions in defects, or the lowest tooling costs). Custom components can be manufactured in high quality and in any production volume. Parts can be manufactured within the same shop for a range of applications, from decorative and architectural to medical and aerospace, and from standard to custom. There is also very little limit to the size, from large to small, of the parts. And, finally, a multitude of material types can be formed in these shops, from industrial to precious, and from ductile to refractory.

931 N. Ridge Avenue, Lombard, IL 60148
Phone: 630.268.9292 • Fax: 630.268.9393
sales@helandermetal.com • www. helandermetal.com