METAL SPINNING

From Ancient Art to High-Tech Industry

BY HANS PALTEN AND DIRK PALTEN

Metal spinning and its spinoffs have evolved into high-tech computerized manufacturing processes.

Today what is classified as spinning encompasses some of the oldest known methods of reshaping materials, derived from the ancient Egyptian art of potting on a wheel. The rapidly rotating, manually powered potter's wheel, in use some 3000 years before the birth of Christ, provided the basis for the art of spinning. Metal-spinning machines have been built for more than 75 years. Development led from hand spinning lathes, to hydraulic spinning machines, to template-controlled machines and, finally, to today's modern playback/CNC-controlled heavy-duty spinforming machines. Now, for example, metal-spinning machines with combined playback and CNC controls (Fig. 1), may cost effectively produce one-off parts out of platinum or huge quantities of aluminum reflectors.

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Hardier & More Sophisticated

A reliable, modern spinning machine must possess a certain mass in order to guarantee stability. This mass ensures vibration-free operation when producing light-gauge parts at high speed, and enables very tight repeatable tolerances in thick-walled workpieces. To complete this range of work, the machinery must provide high spindle-drive capacities, large longitudinal and transverse slide thrust and high forming speeds. In addition, such machinery must be simple to handle and capable of changeover within a short period of time.

Top-of-the-line spinning machines go further. They must be programmable in playback mode, online or offline CNC mode, or even in combination—playback with CNC subroutine.

In playback mode, the first part in a run is manually spun by the operator via joystick and potentiometer. Since human beings show a time delay between optical perception and manu-

Fig. 1—A modern playback/CNC-controlled spinforming machine can produce parts of various materials in varying volumes. Such machines cost-effectively produce prototypes or huge quantities of parts.

Fig. 2—This part was produced using two processes: shear forming for the conical section and spinning for the cylindrical section.

al reaction, the first part can be spun at relatively small feed-rate speeds. The control stores numerous machine movements, including all necessary additional functions such as profiling, machining and cutting, during production of that first part.

If the part meets all requirements, the stored-program speed of the part can be increased to the maximum speed allowed by the material being used. Program optimization is performed either online—directly on the machine—or with offline software.

A Cost-Effective Process

Metal spinning and shear forming (single-forward-pass spinning) boast cost effectiveness through combination of the two techniques (Fig. 2) and through the range of secondary forming or machining operations that can be carried out in the same setup. Compared to methods such as pressing and deep drawing, spinning and shear forming involve lower forces and require less power. As a result, equipment is cost-effectively engineered. In contrast to punches and dies, spinning tools—usually only a mandrel with the contour of the inside of the final part—are inexpensive.

Metal spinning also boasts flexibility. Changes in job processing are made through online or offline program editing. In addition, the simplicity of modern spinning equipment ensures that operators can modify tooling simply and rapidly at a minimum cost.

The process can produce a wide variety of shapes, providing virtually unlimited opportunities for part designers as well as for new applications. Especially where re-entrant shapes are involved, the designer has many options that would be impossible to duplicate with other competitive methods. And equipment manufacturers, through ongoing work to optimize equipment and processes, are achieving ever higher quality standards for spun parts.

Benefits available to users of modern

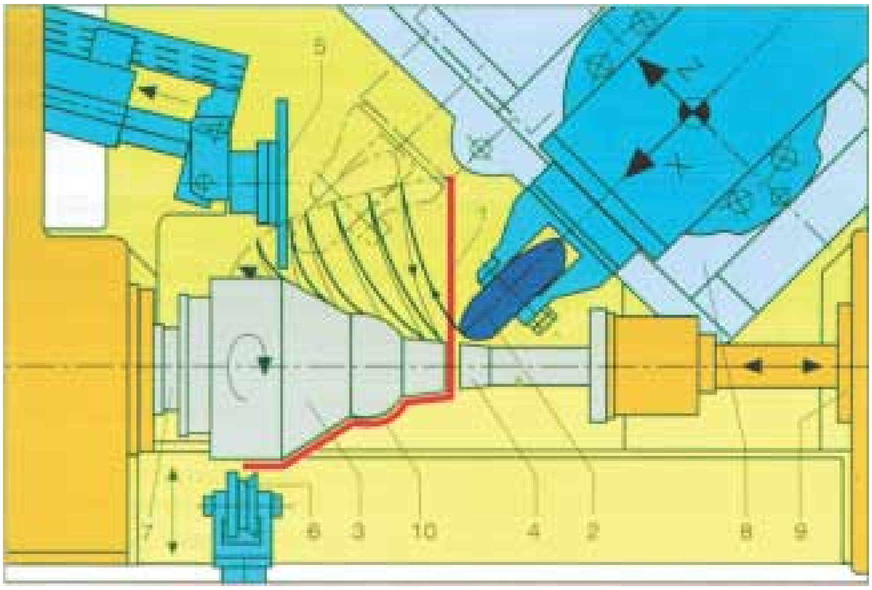


Fig. 3—In multi-pass spinning, a disc blank or preform is clamped against a chuck by the machine tailstock and rotated by the drive motor. The spinning roller, on a two-axis compound slide, makes a series of sweeping motions, progressively forming the metal onto the chuck.

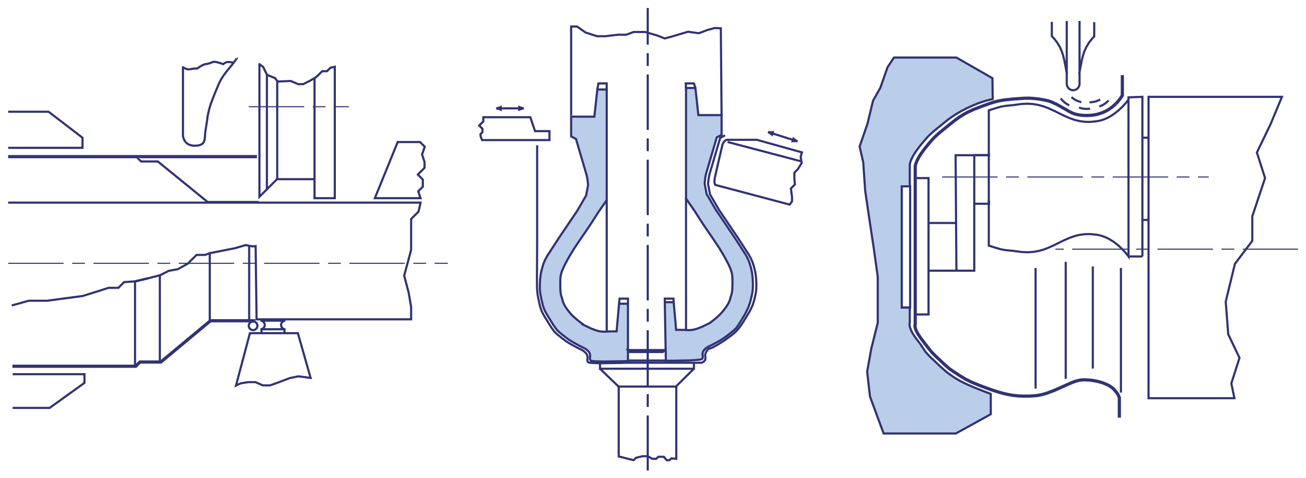


Fig. 4—Reducing, or necking, is a process often referred to as "spinning on air" because most of the time it requires no internal support. In the case of the diagram at the top left, the preform is clamped externally in a retaining chuck.

spin-forming equipment include:

- high flexibility,
- increased level of automation,
- optimum grain flow,
- very low risk of crack propagation,
- high mechanical strength and hardness,
- cost reductions through high material yield,
- variety of operations possible in one setup and
- favorable cycle times.

Whatever the application, spinning and shear forming offer attractive cost benefits. These benefits apply to production of one-offs and prototypes as well as to small to medium runs and, for certain part applications, high-volume manufacturing.

Spinning Methods

Multi-pass spinning. Here, a disc blank or pre-form is clamped against a chuck by the machine tailstock and rotated by the drive motor (Fig. 3). The spinning roller, on a two-axis compound slide, is programmed to make a series of sweeping motions, progressively forming the metal onto the chuck. Auxiliary slides and/or tool changers carry out finishing operations such as profiling, machining, edge trimming, curling, beading and flanging.

Reducing (Necking). Often referred to as "spinning on air" because it requires no internal support, this process involves re-entrant shapes where form and finish are secondary (see Fig. 4). For higher part quality or when

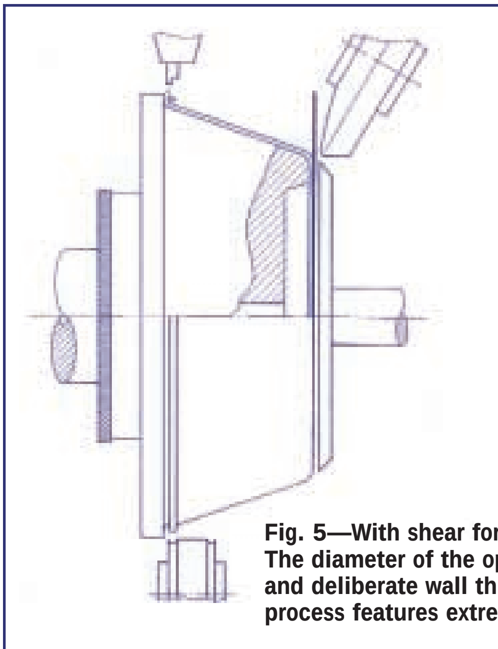


Fig. 5—With shear forming, conical, concave and convex parts are produced in a single pass. The diameter of the open end of the cone corresponds to the initial diameter of the disc blank, and deliberate wall thinning takes place as a direct function of the angle of the cone. This process features extremely short cycle times.

using internal segmented tooling, the process can employ an eccentrically mounted internal roller.

Shear forming. In this metal-forming variant, metal is volumetrically displaced in an axial plane (Fig. 5). In a single pass, conical, concave and convex parts are produced whereby the diameter of the open end of the cone corresponds to the initial diameter of the disc blank. This process features extremely short cycle times (Fig. 6). Deliberate wall thinning occurs as a direct function of the angle of the cone. The reduction in wall thickness follows the formula:

S1 = So x sine α

where

S1 = wall thickness of finished part

So = blank thickness

α = shear angle (see Fig. 7).

Shear forming is ideal for conical, concave and convex hollow parts with symmetrical contours within shear angles from 12 to 80 deg.

Shear forming offers a remarkable increase in part strength due to cold working. During forming the material displaces axially. Knowledge of the plastic behavior, therefore, is an elementary requirement in shear forming.

Fig. 6—This 15-in.-dia. 9-in.-deep copper cone was produced, via shear forming, in 48 sec. from a flat blank. Forming of the cylindrical area and the beading operation occurred in the same cycle. Multi-pass spinning this part would require a cycle time of 2 min.

Material strength resulting from plastic deformation often is seen as a design improvement. For example, when shear forming a part with a 30-deg. angle, cold-work hardening is responsible for strengthening 16-gauge mild steel material the same structural strength of 11-gauge mild steel. In this example, about 50 percent of material can be saved in the shear-formed cone area.

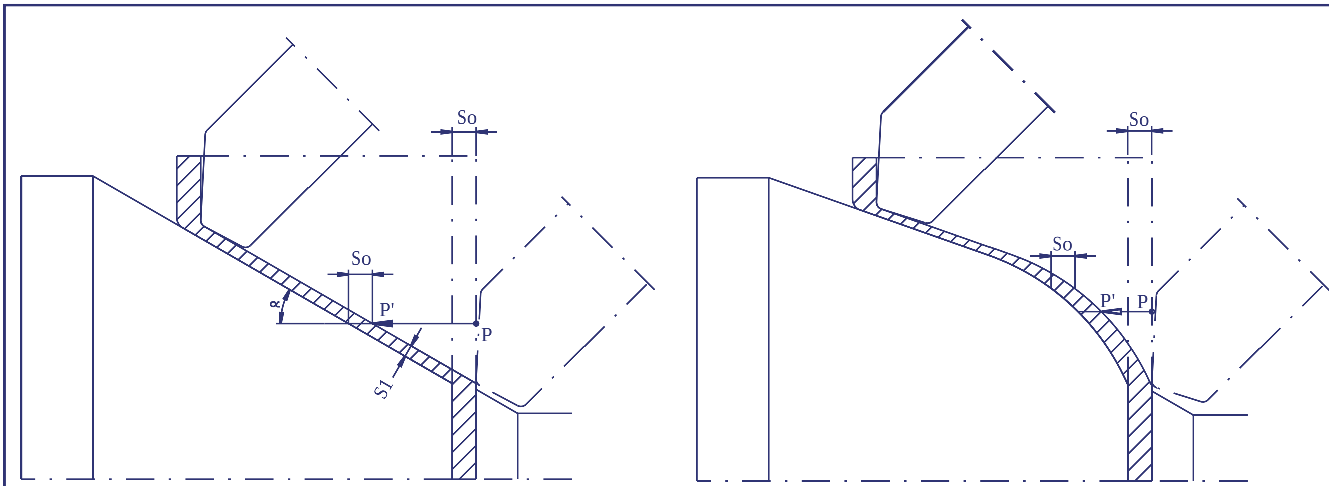
Besides such material savings, shear-formed parts can be produced within rapid cycle times and with ideal surface finishes. Designers early on should determine if a part will be produced through multi-pass spinning or shear forming.

Flexible Production and Rapid Setup Times

Over the past three decades, spinning, with its use of playback/CNC spinning machines, has become highly competitive with pressing and deep drawing. Advantages of spinning include flexible production, relatively low tooling costs, rapid and economical adjustments to tooling and programs, and short set-up times. By selecting from a range of auxiliary machine attachments, the latest-generation spinning machine becomes a versatile spinning center.

Modern machines are simple to operate and can carry out, in a single cycle, multiple operations including planishing, profiling, curling, beading, seaming, trimming and machining.

When designing new production parts, keep in mind the different spinning methods, especially shear forming, which offers cold-work-hardening advantages, material savings, ideal surface finishes and rapid cycle times. **MF**



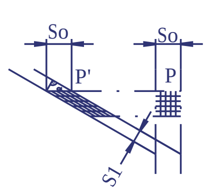


Fig. 7—In shear forming, the reduction in wall thickness follows the following formula: S1 = So x sine α; where S1 = wall thickness of finished part, So = blank thickness and α = shear angle. P and P´ show how the material shifts in the process. Shear forming is ideal for conical, concave and convex hollow parts with symmetrical contours within shear angles from 12 to 80 deg.