# Spin-Casting: A Prototype and Short Run Casting Process

***The ancient art of spin-casting has moved into the 20th century in full force. With the development of high temperature, heat-cured silicone rubber molding compounds, high grade zinc aluminum alloys, and a vast assortment of urethane and polyester casting resins, spin-casting has become a major alternative for prototyping and short run production.***

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Anyone who has ever designed or developed a product eventually comes to a point when they need prototype parts. Whether the prototypes are to critique and modify, to obtain customer approval, to enable preproduction testing, or to support advertising efforts, they are required. Machining parts can be a time consuming, expensive experience. This is especially true when parts are highly detailed, contain free forms, inside square corners, or other difficult to machine features. Often, design changes must be made to accommodate machine shop limitations, thus losing the essence of the design.

Consider the part shown in **Figure 1.** Two hundred nonstandard bevel gears were required to get through preproduction testing and approval before hard tooling was released. Machining two hundred parts would require lathe and gear-cutting operations, and would be very expensive. It would also involve the sacrifice of settling for machinings when castings were required for accurate preproduction testing.

What is the alternative? Spin-casting, a prototype and short run casting process designed to enable engineers and designers to review their designs, debug them, and proceed into production with confidence. The spin-casting process uses vulcanized silicone rubber molds and centrifugal force to produce highly detailed castings in a variety of technical grade materials. As a prototype and short run manufacturing procedure, it has few application limitations. Almost any part that is designed for other casting processes can be produced by the spin-casting process in an inexpensive, timely fashion.

## Making the Mold

Spin-casting molds are made from silicone rubber. The raw rubber starts out as a "green" or "B stage" putty and is calendered into flat, round discs, approximately ¼ inch thick **(Figure 2.)** The discs are laminated together to form an upper and a lower half. Then, the shape of the casting to be produced is carved into the rubber, around the perimeter of the mold. In many cases, part of the carving is in the upper half and part in the lower half. You may ask, "Why do you have to carve the shape into the rubber?" It is carved in to control the parting line. You see, once the carving is complete, models are placed into the carved-out area, the mold is closed, and loaded into a steel flask for vulcanization. During vulcanization, the mold is subjected to 335°F and 3000 to 4000 pounds of pressure for several hours. This causes the "B stage" rubber to liquefy and begin to flow. Carving the rubber helps eliminate turbulence which can occur during the liquid stage. If a good fit were not obtained first, turbulence might occur during vulcanization, distorting the parting line, and disorienting the part.

Once the rubber passes through the liquid stage, it cures to a tough, flexible, heat-resistant rubber. The mold is removed from the flask and allowed to cool, during which time some shrinkage occurs. The model is then removed and a sprue is carved into the center of the mold. This sprue serves as the main distribution center of casting materials. Finally, the ingates and vents are carved in and the mold is ready for spin-casting **(Figure 3)**.

## Casting Procedure

The spin-casting process relies on centrifugal force to create the pressure that forces the casting material into the cavity. In fact, centrifugal force is the key to spin-casting. In the case of zinc alloys, this force is crucial in obtaining low porosity, medium density castings. For plastics, centrifugal force helps eliminate voids.

The casting process begins in a machine called the spinner **(Figure 4).** A mold is manually loaded into the spinner and clamped down with 20 to 40 pounds of pressure. Once secured by the clamp, it begins to spin at a preselected speed ranging from 200 to 1000 RPM. Molten metal or liquid plastic resin is then poured into the center of the mold called the sprue, while the mold is rotating. This rotation forces the material outward, through the

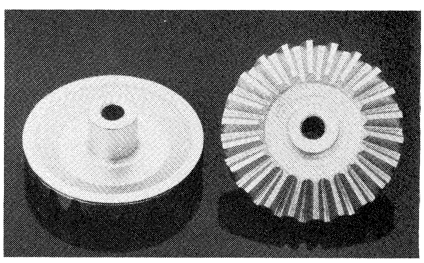
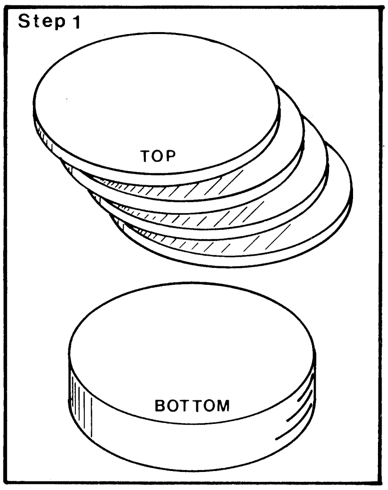
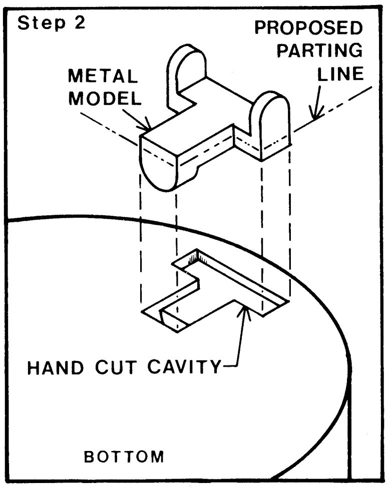


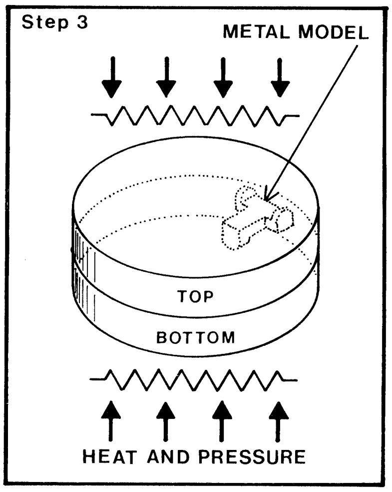
**Figure 1.** *An eight cavity tool was used to produce the 200 gears required. The tooling cost was $420.00 for the rubber tool, and yielded 240 castings at a piece part price of $6.60. Eight metal models were needed to produce the tool.*



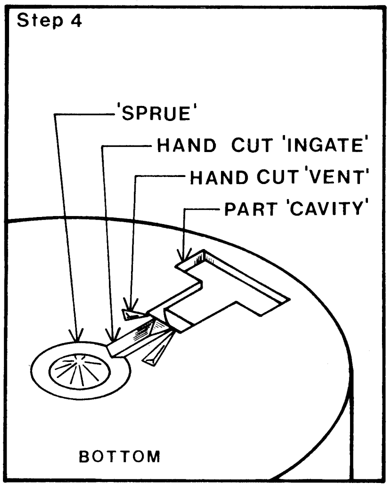

**Step 1:** *The mold is constructed from multiple layers of putty-like "B stage" silicone rubber. The thickness is determined by the size of the part.*




**Step 2:** *The cavity is hand carved into each mold half so that the model fits neatly into the cutout. Carving is required to control the location of the parting line.*




**Step 3:** *A metal model of the part is placed into the carved-out area and the mold is closed. The rubber is then vulcanized under heat and pressure to cure it.*




**Step 4:** *The vulcanized rubber mold is opened and the metal model is removed. The sprue, ingates, and vents are hand cut in and the mold is ready for use.*

**Figure 2.**

ingates, and into the cavity. Note from **Figure 2, Step 4,** that the position of the hand cut vents are close to the ingate. When the material enters the cavity, it back fills. This forces the entrapped air back towards the sprue and eventually out through the vents.

Once the material has entered the cavity, there is a waiting period while the casting material solidifies. this will vary depending on the casting material used. For example, a zinc alloy may take 30 to 60 seconds to set up while a quick-set urethane may take 5 to 10 minutes. After the material has set, the spinner is opened. This stops the spinner from spinning. The clamp pressure is released, and the mold is removed from the machine. The mold is opened and the castings are carefully removed. This is all done manually. Care is critical at this stage because damage can occur to the mold. Remember, the mold is soft and flexible and is subject to scratches, tears, and wear. The more carefully the parts are demolded, the longer the life of the mold. Once the casting process is complete, the mold is prepared for the next cycle. When zinc alloys are cast, a mold cool down is required. Allowing the mold to overheat can cause swelling and distortion to the rubber. Plastic molds normally require preheating and the application of a mold release. As soon as the mold is prepared, the process begins again.

## Examples

There are few limits to the variety of prototype and short run applications for spin-casting. Take for example the case shown in **Figure 5.** This two piece instrument case is produced in a rigid urethane. It is approximately 4.950″ long, 1.500″ wide, and 0.600″ high when assembled. Thirty assemblies were required to get through the prototype stage. Prototyping was required to troubleshoot the design before investing in the hard tooling. One two cavity tool was needed to produce thirty sets. The cost of the tool was $390.00, the piece part price was $28.00/two piece set, and the project was completed in 2 to 3 weeks. The internal components were assembled, tested, and several design changes were made before being released for hard tooling. It is important to note that the casting material used for final production was not urethane. However, urethane was suitable for a simulation of the final product.

Spin-cast parts are also used for short run production. Many products are not mass produced, such as medical equipment, robots, and small custom equipment. A good example is the small zinc alloy castings shown in **Figure 6.** Several hundred parts were required per year to fulfill customer requirements. Note the small threaded stud shown in the middle of the picture. This stud is intercast in place and is shown in the left hand view. If four cavities were running simultaneously, the piece part price would be $4.45. If eight cavities were running, the piece part price would drop to $3.80. Piece part prices normally depend on the size of the part, the quantity required, the difficulty level, but most important, the number of cavities running. The more cavities running, the lower the piece part price. However, there is a maximum number of cavities that can fit into a mold.

In addition to intercasting, many other diecasting and injection molding capabilities are possible using the spin-casting process. Cores can be used to produce complex internal features that would normally require a four-slide die construction. An example of a multiple cored part is shown in **Figure 7.** The finished urethane casting is shown on the right. The core set used to create the internal features is shown in the center, and the model used to create the image in the rubber mold is shown on the left. Note that the cores shown in the middle view interlock.

## Cores

Cores are regularly used in spin-casting to produce complex internal and external shapes. **Figure 8** shows the graphic sequence of how to cast a square hole into a part using a core. Starting at the top, the finished model is shown with a square core pin print feature. The second drawing shows the model fabrication technique. The square core print shape is produced without machining the part in one piece or broaching a square hole through the model. Square bars are simply pinned to the part shape. A core print is required to seat the core pin in the mold. It must be fairly substantial to hold the core pin in place while the mold is spinning. The third drawing shows a mold cavity with the core pin in the core print, or seat. And finally, the last drawing shows the finished casting complete with its square through hole.

## Models

Models are required to produce the cavities in vulcanized rubber molds. As previously discussed, these metal models are placed into the rubber prior to vulcanization. When the rubber liquefies, it captures every detail of the model. Once the vulcanization stage is complete, the model is removed.

The models required for vulcanized rubber molding should be made from metal capable of withstanding the high heat and pressure exerted during vulcanization. The model(s) can be fabricated in one piece or in sections, provided the sections are mechanically fastened together. Press fits, screws, pins, and solder are all acceptable fastening methods. However, the use of adhesives of any type is not recommended because they can react adversely with the silicone rubber. They can also lose their strength at the elevated temperatures used during the vulcanizing process and the sectional model could literally float apart.

As with most casting processes, shrinkage must be considered when fabricating models. Spin-casting models must be made oversized to account for the shrinkage that occurs during vulcanization and during casting. On the average, the shrink factor is 1.5% or 0.015 inches per inch. However, each part should be evaluated individually to determine the appropriate shrink factor.

## Metal Alloy Casting

Several metal alloys can be processed using rubber molds. However, the most suitable for industrial applications are the zinc aluminum alloys. With high

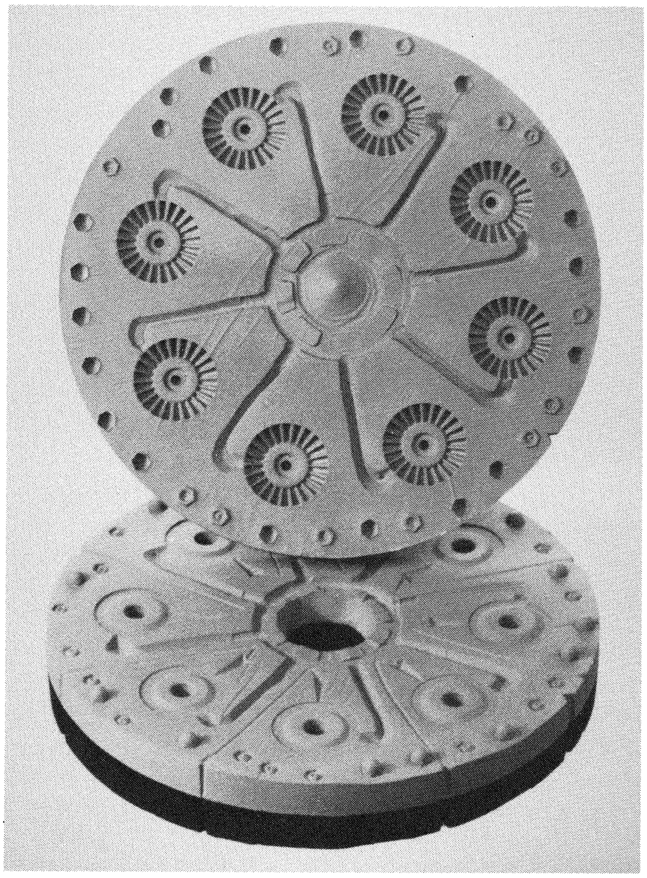


**Figure 3.** *This 8 cavity tool was used to produce the castings shown in **Figure 1**. Note the holes and buttons located around the outside perimeter of the mold. They are used to keep the mold aligned during casting.*

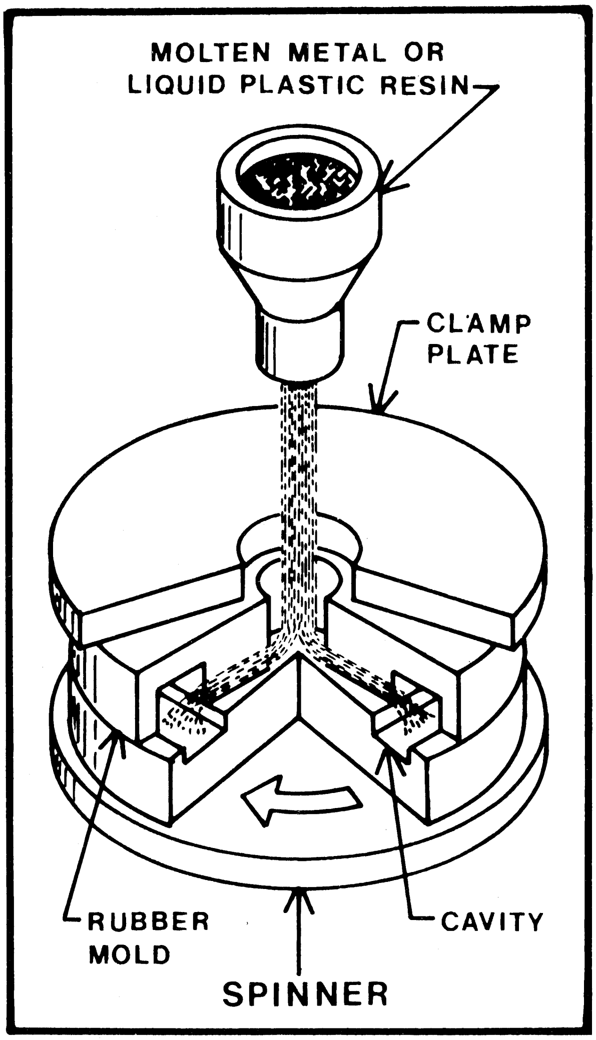



**Figure 4.** *Schematic drawing of the spin-casting process.*

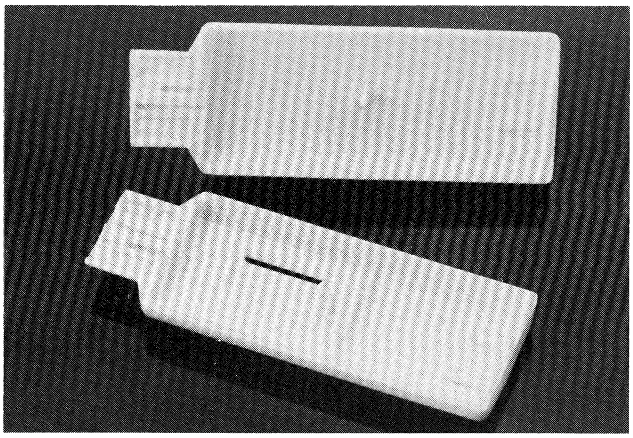


**Figure 5.** *A 2-piece urethane case.*

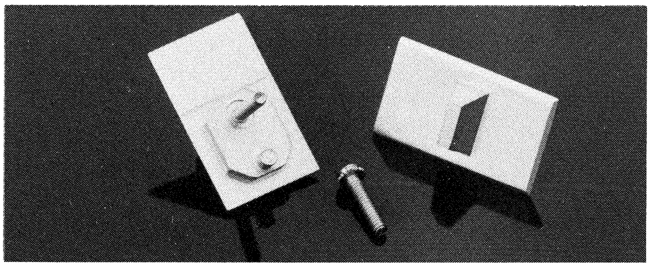


**Figure 6.** *Zinc alloy slide knob with an intercast 4-40 threaded stud.*

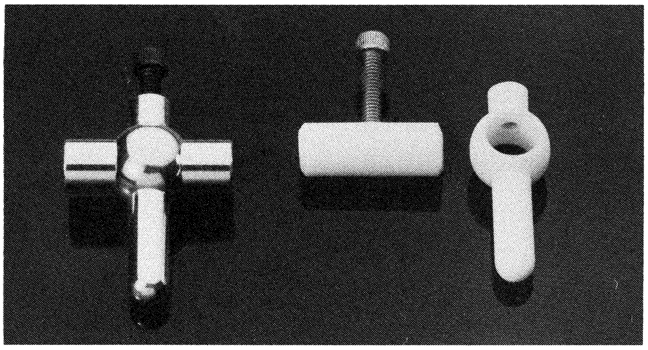


**Figure 7.** *A urethane medical instrument part, 1.750" long with a through hole and a 6-32 tapped hole cast in place.*

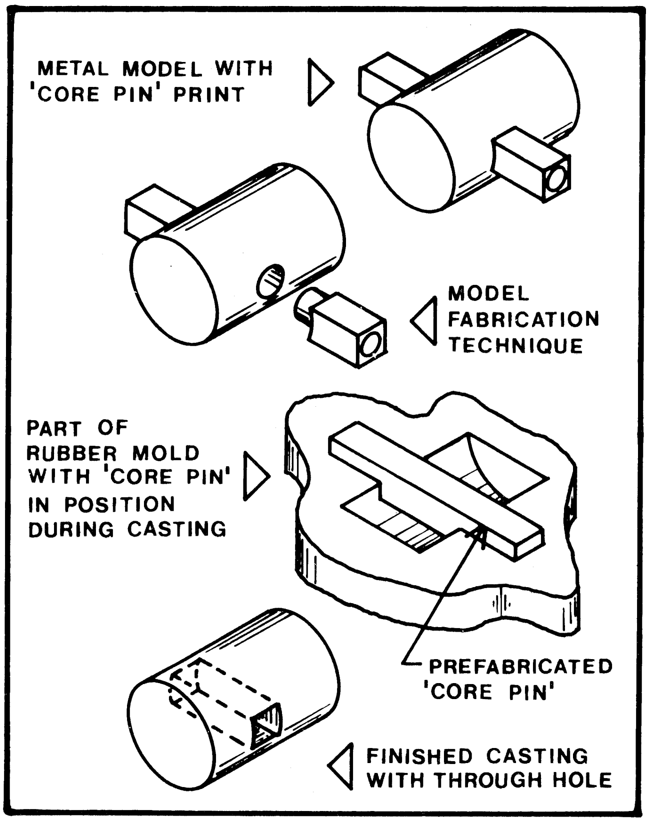



**Figure 8.** *Manufacturing sequence to produce a cored hole through a casting.*

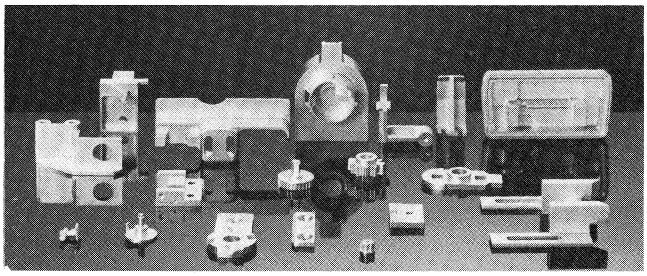


**Figure 9.** *A group of small zinc alloy castings.*

aluminum and copper contents, these alloys have gained industrial acceptance as a standard casting material **(Figure 9).** Keep in mind, they are not to be confused with the white metal alloys used by the auto industry early in this century for ornamental parts. Zinc aluminum alloys are highly refined, industrial grade casting alloys. They are electrically conductive, thermally conductive, wear resistant, impact resistant, and strong. They are also easily machined, plated, and painted. You can see in the comparison charts **(Figure 10)** how these alloys compare to cast aluminum, and machining grades of aluminum, brass, and steel.

The melting temperature of the zinc aluminum alloys is also well suited for spin-casting. Casting temperatures range from 700°F to 800°F. This is a crucial element in the value related analysis of rubber mold casting yields. Since heat deteriorates the rubber mold, the lower the casting temperature, the higher the yield.

Other metal alloys that spin-cast well are the bismuth and tin-lead based alloys. A practical application using the tin-lead based alloys are solder preforms, which are regularly cast in rubber tooling.

## Plastic Resin Systems

The most practical spin-castable plastics are the urethane resin systems. They are two component systems that catalyze when mixed together. It is important to note that all plastics must enter this system in a liquid form. They are poured into the sprue while the mold is rotating. Injection grade plastics such as PVC or ABS cannot be cast using this technique because they are only available in granular or pellet form and cannot be poured. The injection pressure required to cast these thermoplastics is not available. The thermosetting liquid resins are simply poured into the spinner while the mold is rotating. The centrifugal force, which generates 8 to 10 pounds of pressure, is enough to fill the cavities with plastic and expel the air.

Urethanes can be used to produce a variety of technical parts **(Figure 11).** They are tough and impact resistant. Finished casting durometers can range from the rubber-like Shore A 30's to the rigid Shore D 90's. Even flame retardant and flame resistant castings can be produced. They look and feel like thermoplastics and are an economical solution for prototype and short run plastic production.

## Mold Life

Each casting material affects silicone rubber in a different way. While metal tends to burn the rubber with its heat, plastics petrify it with its chemical reaction.

When considering metal, the temperature of the metal, the size of the part, the average wall thickness, the depth of its draw, and the draft all contribute to mold life. Heavy wall, large parts will destroy the mold cavity much faster because the heat density will be higher than a thin part. Mass relieved parts with uniform walls, approximately 0.090″ thick, will maximize mold life. Keep in mind, ribs and other strengthening features can be easily added.

There are two main causes of mold deterioration when casting plastics. First, chemicals migrate from the resin/hardener mixture into the rubber. Although mold releases are used to protect the mold, penetration still occurs. Second, exothermic heat is generated as the plastic cures. The combination of the chemical migration and the exothermic heat progressively damages the skin of the rubber mold. It eventually becomes brittle and breaks apart.

To summarize, mold life is determined by the casting materials being used and the physical characteristics of the part. Molds producing zinc alloy castings will yield from 25 to 100 castings per cavity. Those producing plastic will yield 25 to 40 castings per cavity. In general, if good die-casting practices are applied when designing the part, mold life will be maximized.

## Design Flexibility

A compelling advantage of spin-casting is the flexibility and freedom it offers product designers from fabrication limitations. It is no longer necessary to eliminate key details from a design just because they are too costly to machine in small quantities. Parts may be cast with all the form, fit, and functional requirements of the final design.

The ability to trouble shoot designs before investing in hard tooling is another spin-casting advantage. For example, **Figure 12** shows two varieties of the same part. Shortly after the first group of spin-cast parts arrived, the decision was made to change the design. What had originally looked good on paper was not good in production. A second part was designed, a longer version, and all that was lost was a few hundred dollars worth of rubber tooling. Spin-cast parts helped eliminate the losses that would have occurred if the hard tooling had been cut from the original design.

Finally, the designer can take advantage of the molding process by adding esthetic grains, grooves, company logos, and identification markings, either in a raised or recessed manner. These extras need not be carved into the rubber during mold making. They are picked up easily by the rubber when it liquefies. They are essentially free of cost beyond the additional work required on the model(s).

## Limitations

Spin-casting, as with all processes, has limitations. Size is the main limitation of spin-casting. Any part that fits into a 4″ x 6″ x 2.750″ rectangle can be produced; however, the process best serves the small casting market.

The diversity of casting materials is the second limiting factor. Any metal that melts below 900°F can be cast. This is not to say that the 8 to 10 pounds of pressure created by spinning will yield the optimum results of the metal. For instance, most of the tests performed on the Zamak alloys are done on diecast samples. These alloys can be processed but may not yield the same mechanical characteristics. There are alloys specifically designed for spin-casting so that mechanical requirements can be met with low casting pressure. Plastics are also limited to the thermosetting

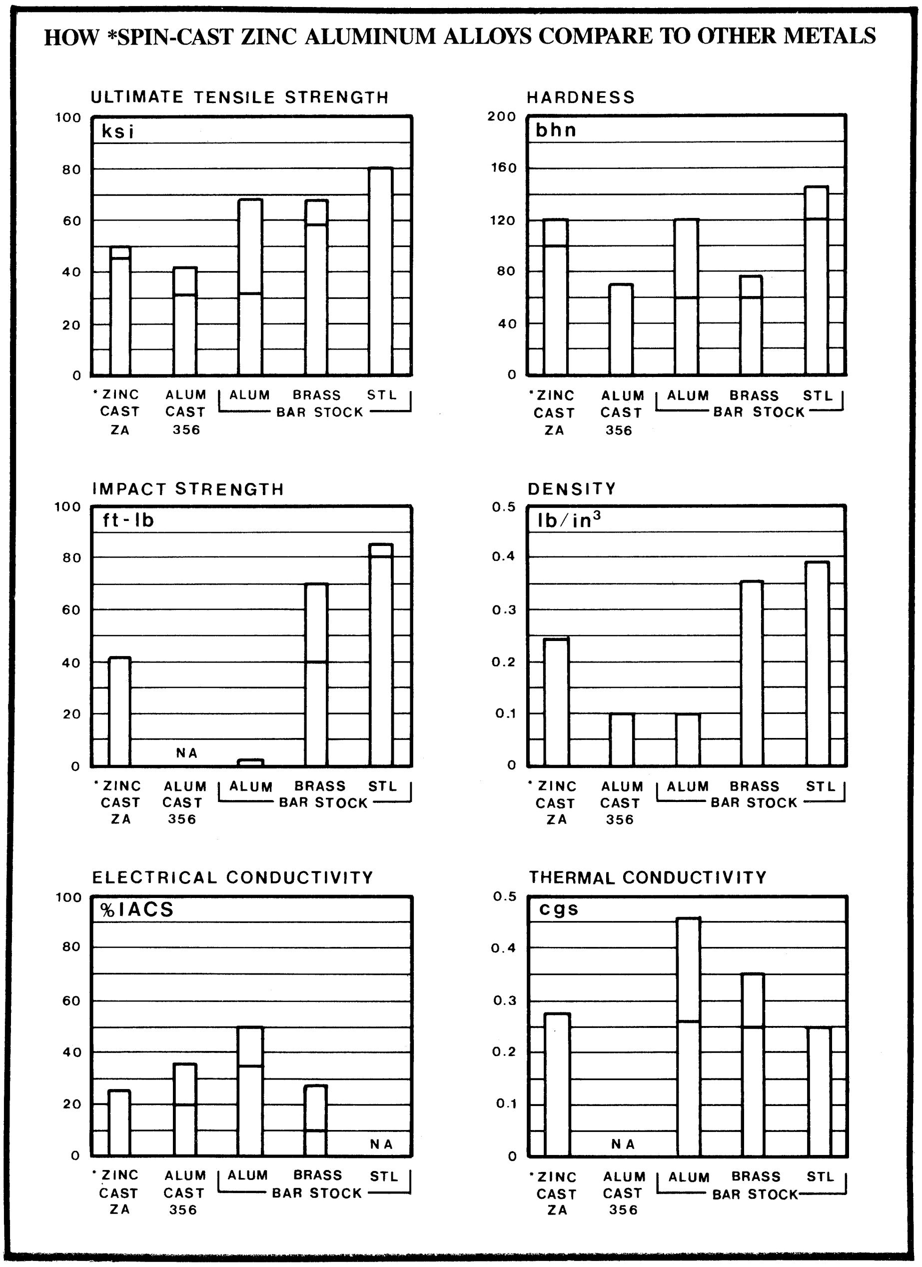



Figure 10.

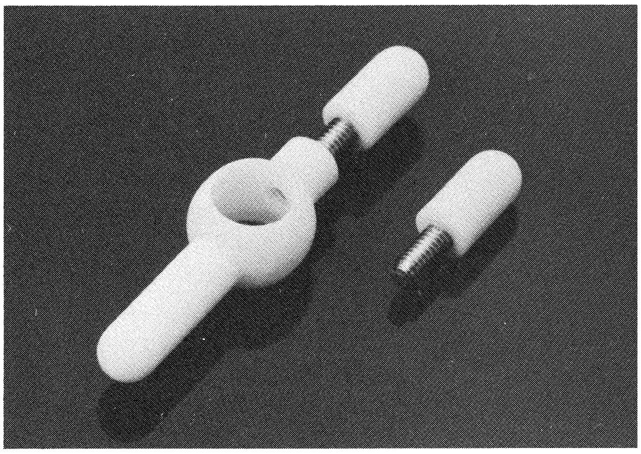


**Figure 11.** *These parts are produced in white urethane. One part has an intercast threaded stud and the other has a cast 6-32 threaded hole.*

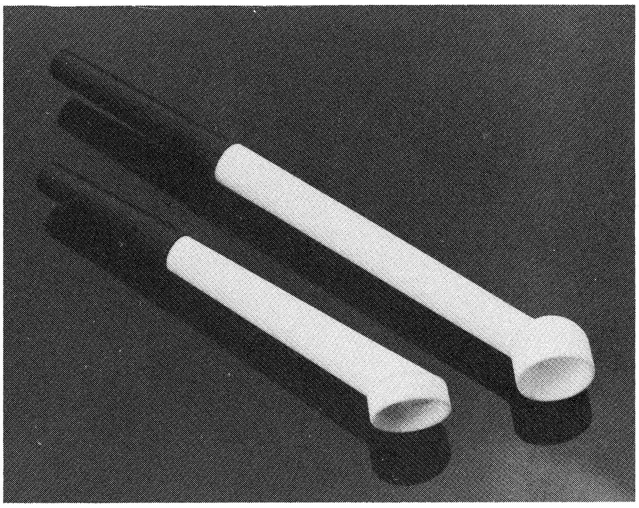


**Figure 12.** *Two designs of a urethane handle.*

plastics. Most any plastic that is available in liquid form can be processed in rubber tools.

The final major consideration is dimensional stability. The rubber tooling used is susceptible to the stresses and movement caused by the spinning action. The temperature and weight of the casting material can also affect the mold. In general, tolerances of ±0.005 inch on all dimensions under 1 inch and ±0.005 inch per inch thereafter prevail. Where tolerances must be held tighter, secondaries can be used to complete the part.

## Summary

The spin-casting process is a unique solution to a problem that has plagued engineers and designers for a long time. How do you get the prototype and low volume production needed to produce the product easily, inexpensively, and quickly? You spin-cast them. Once the capabilities and the limitations are understood, this casting process can become one of the most useful tools available.