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A BNP Publication
www.assemblymag.com

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Forming *in Circles*

Orbital forming offers an efficient and precise method for assembling component parts.

This multipoint orbital unit flares out four semipierced posts simultaneously to secure a speaker basket stamping to the magnet without damaging the brittle magnetic material.

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Orbital forming has been used to assemble component parts for 40 years, and the use of orbital forming in production is increasing. Orbital forming is a clean, silent, nonimpact and vibration-free coldforming process that forms heads on most malleable materials quickly. The orbital forming process provides a strong joint with an attractive finished appearance, and batch-to-batch uniformity.

An orbital forming machine flares or forms heads on studs, pins, posts, hubs and tubing, as well as on rivets and other loose fasteners. Parts joined with a single pin can be left free to rotate about the axis of the joint, or clamped rigidly to inhibit rotation. If one or more shoulder pins must be secured to a blanked plate, a single-spindle machine can be used to secure one pin at a time or a multispindle machine with appropriate multiple tooling can secure all of the pins simultaneously.

Applications

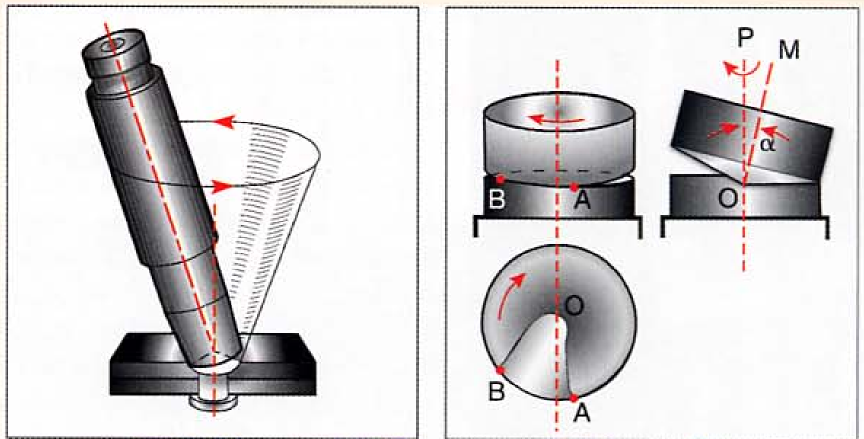
Assembly applications for orbital forming are diverse. About 35 percent involve joining components, either rigidly or allowing one degree of rotational freedom, by flaring or heading pins, studs, posts, shafts, and similar parts. Another 20 percent involve heading solid or semitubular rivets, eyelets, and even threaded fasteners, often made of stainless steel or coated material.

About 40 percent of applications do not involve loose fasteners. Half of these applications are jobs that call for forming, crimping or swaging tubular components such as cans, bushings, sleeves and tubing as large as 4 in. OD. The other half are jobs in which die cast, molded or machined bosses, studs, tabs or other features integral to a component are headed to retain other components. Finally, about 5 percent of applications involve jobs like embossing, marking and coining.

Orbital forming can eliminate the need for separate hardware or loose fasteners. Blanked or diecast ridges,

Typical parts assembled without the use of loose fasteners. Integral diecast studs, pins, tabs or bosses are flared or headed by orbital forming to secure mating parts.

bosses and integral projections of malleable material or an engineering thermoplastic can be formed out to anchor components in position. For example, a leaf spring can be captured on a stamping by flaring out two blanked rib sections with a single form tool. Bent-up tabs on a stamped



Forming in Orbit

In orbital forming, a form tool is mounted off-center in a rotating spindle, with the form tool axis at an angle—typically 3-6 degrees—to the spindle axis. The form tool axis intersects the spindle axis at the working end of the tool. The machine spindle rotates, but the form tool itself is free to rotate in its bearings, so the form tool orbits the workpiece but it does not spin.

The rotating spindle advances axially, bringing the tool into contact with the workpiece. The form tool is forced against the workpiece under a preset, constant pressure for a predetermined length of time to form the desired shape. The line contact between the form tool and the workpiece never varies. At each rotation of the spindle, the same line of contact is maintained to flare the workpiece material radially. Because the same point on the form tool is always in contact with the same point on the workpiece, almost no friction occurs and no tearing of the work material results, regardless of whether the workpiece is solid, tubular, triangular, square, hexagonal, oblong or semicircular.

mounting plate can be designed as spacers that fit through matching holes in a mating cover plate. These tabs are then flared to secure the assembly without fasteners.

Holes in D or double-D configuration can be blanked in a plate to provide specific part orientation. Shafts or tubes with the matching D or double-D shape protrude through the plate and are headed to secure the parts both in place and in the correct orientation. Similarly, round shoulder pins can be flared in punched square holes of a mating plate. Material flows into the corners of the square holes, creating a torque-resistant joint. This can yield considerable cost savings because studs, posts and shafts turned from round stock cost less than milled parts in square, rectangular, D or double-D shapes. Furthermore, multiple round posts protruding through punched holes can be headed simultaneously.

Process Details

As a rule, shorter cycle times in manufacturing operations result in better production rates. In general, cycle times for orbital headforming run from 0.5 to 2.0 seconds on solid steel studs of higher tensile strength. This includes tool approach, form tool dwell and spindle return, but not part loading. Generally speaking, the softer and more malleable a material is, and the smaller its diameter, the shorter the work cycle. However, even on steel pins 1 inch in diameter, cycle times are about 2 seconds. When automatic slider plates or index-type fixturing are used, the time required to load parts manually or automatically has a larger impact on production rates than does cycle time.

Heading capacity for any size of machine is governed not so much by the diameter of the part as by the total surface area to be formed and the tensile strength of the material. For example, a machine that can flare a 5/16-inch diameter solid shoulder pin made of mild steel can also swage over the shell of a size D flashlight battery to crimp or seal its end. It can also flange a 3-inch diameter hollow aluminum body with a wall thickness of 0.03 inch.

Typical orbital forming machines allow setting cycle time and heading pressure for specific tasks. A combination of preset pressure and cycle time is usually appropriate in cases where two or more parts to be joined by studs, pins or rivets are subjected to broad tolerance variations, or when a brittle base component, such as ceramic, glass or phenolic, is involved.

The spindle stroke is typically controllable within increments of 0.001 inch. This makes it possible to form rigid joints, firmly fixed joints with selectable torque resistance, or smoothly moving swing joints. For example, products including pliers, scissors, pocket knives, gear trains, bobbins, handcuffs, and virtually any other swing-joint assembly can be produced with "tight swing," "loose swing" or "floating" joints as desired. The machine controls allow the end user to produce a joint with virtually any degree of torque resistance required.

Most orbital headforming operations usually require a few minutes of work by a setup person, along with some trial-and-error to establish operational parameters. After the machine is set up and its controls are set to automatic mode, it can be operated by skilled or unskilled workers.

Tools and Fixtures

Parts placed or fed into the fixture of an orbital forming machine usually can be left freestanding and require no clamps or hold downs. No spinning force is transferred from the spindle to the parts, so the parts remain where they are placed throughout the cycle. For example, a two-plate assembly to be joined by one rivet usually requires a simple locating nest with a pocket to position the preformed rivet head. To

Cross-section of tubular end of one part flared over by orbital forming tool to capture a ring securely.

orient or to secure spring-loaded parts before and during the assembly process, a hold-down device can be mounted on a single tool or multipoint forming head.

Hard-to-reach pins, shoulder studs and similar parts can be secured close to a vertical wall or in a recess of a part. The reach of the form tool is limited only by the clearance around it while it is orbiting. Changing the angle of the form tool in the spindle by as little as 2 degrees can reduce the clearance requirement.

Many variations of multiple-point forming on a single work piece, or gang heading multiple parts, are possible. An orbital headforming machine can be configured to carry as many tools as needed, and with centers as close as 3/16 inch on centers, to meet multitask applications. Large multispindle systems may have tooling plates up to 20 inches across, often with tools working at different heights or heading levels and on more than one part simultaneously. Changeable tooling sets allow simple conversion from one heading pattern to another. Standard multiple forming attachments, including in-line and random pattern tooling and two, three, and four variable center distance spindle heads, fit most machines.

Because the orbital forming process is nonimpact, tools sustain little wear. Instead, the process action causes the formed ends to become polished, work hardened and nearly maintenance-free. A flat-faced tool to form mild steel studs may last for years without requiring any maintenance. For more complex tool shapes or those that are used on certain aluminum or brass grades, periodic polishing may be required.

Material Issues

In general, any malleable material up to Rockwell 35C can be formed orbitally. This includes most ferrous and nonferrous metals, stainless steel, zinc and aluminum die-cast material and some sintered metal parts. Orbital forming is ideal for use on engineering thermoplastics. Polymers and composites that feature the rigidity and dimensional stability for cold forming include ABS materials such as Cycolac, Magnum, Lustron and Bayblend; some polyamides such as Nylon and Durethan; polycarbonates such as Lexan, Makrolon and Calibre; and polymer acetals such as Delron, Celcon and Ultraform.

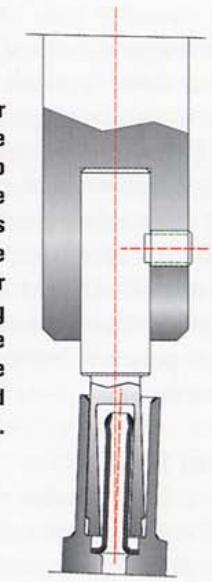
By contrast, thermoset plastics such as alkyds, epoxies, Melamine, phenolics, polyesters, polyurethanes and silicones are not amenable to orbital forming. Polyetherimide and other amorphous resins are also unsuitable, typically because of their crystalline structure, limited malleability or poor dimensional stability.

Casehardened steels and plated, painted or plastic-coated materials can usually be orbitally headformed, because material displacement is microscopic during each tool rotation. After orbital headforming, the coating surface is usually left in its original condition. The luster of some plated surfaces actually improves. Photomicrographs show that orbital headforming does not disrupt the molecular structure of metals.

However, orbital forming cannot be used on materials such as high-carbon high-chromium tool steels, which may have a hardness up to Rockwell 60C. It is also ill-suited to forming good-sized round heads on rivets made of titanium or heat-resistant alloys such as Inconel, Hastelloy or Waspaloy because of the high tensile strength and poor malleability of these materials.

Compressing the grain structure work hardens the material somewhat. This can be beneficial in that it results in a stronger connection for studs, pins and rivets, or a harder contact surface in the case of flared, flanged or swaged parts. **A**

Recessed and other hard-to-reach parts are often amenable to orbital forming. The reach of the tool is limited only by the clearance required for its orbit, and changing the tool angle by as little as 2 degrees can reduce the clearance required significantly.



Although many orbital forming applications involve heading loose fasteners, the process can also be used to assemble components with integral fasteners. In this example, semipierced studs on a fine blanked part are flared over a mating plate.