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Holding On

Collets often are considered yesterday's technology. As workholding devices, collets date back to colonial times; Benjamin Franklin reportedly used collets to hold optical lenses during grinding and polishing operations.

Even though collets' roots are firmly planted in the past, they remain an integral part of today's tooling designs. Millions of collets—small, large, basic and exotic—are produced annually.

It's always good to revisit the basics of collets during the design and routing phase of a workholding project. Without a clear vision based in sound theory, it's hard to apply collets properly.

Misapplication is still the main reason for collet failure. Collets are repeatedly asked to do more than they were designed for. Sometimes a collet is made of a material that was never meant to withstand a particular application. Improper material specification is the hardest and most costly error to detect.

A Lesson in Style

Workholding collets are available in three basic styles: push, draw and compression.

The most common is the push collet, which relies on a locknut that resists pressure applied by a sliding tube or socket. The socket or tube has an ID pressure angle, which mates with the collet's angular design, and, pushing the socket forward, compresses the collet. The most popular push collet is the "B" type, which is typically for an automatic screw machine that consumes a large quantity of bar stock.

The second most common style is the draw collet. A thread is machined into the collet's end opposite the pressure angle. The collet is secured and/or drawn into a tapered socket by the thread. This applies pressure to the collet's angular design, causing the collet to grip the workpiece. The most common draw collet is the C-type, such as the popular 5C. C-type collets are generally for secondary machining where parts are loaded by hand.

The third style is the compression collet. Compression collets rely on a special nut normally found on the end of a spindle and/or toolholder. The nut, when turned, compresses the collet into the ID taper bore and causes the collet to collapse around the item being held. Compression collets primarily hold cutters, but, occasionally, they also hold workpieces. These collets are commonly referred to as ER, DA, TG and AF.

Modern workholding systems incorporate many types of clamping devices, such as chucks, vises, strap clamps and collets. They have overlapping characteristics. For instance, they all can hold round, flat and contoured parts.

All photographs: Zagar Inc.

The three basic styles of collets (left to right): push, draw and compression.

One area where they differ, though, is their relative effectiveness at holding differently configured parts. A collet, for example, would be more effective at gripping a round workpiece than a vise would be.

The ability to machine soft jaws mounted to a chuck or vise is possible with collets. Soft, blank collets and pads can be machined in place. This technique reduces misalignment caused by a worn spindle and/or table assembly, as well as the accumulation of multiple part tolerances.

Soft collets are also handy for quick and unexpected clamping requirements. Therefore, they're sometimes referred to as "emergency" collets.

From time to time we have been told that if a collet system is specified, each machine in the production line requires numerous sizes and sets

C-type collets are generally for secondary machining where parts are loaded by hand. Picture is a 22C ID collet.

The collet—the 'other' workholding device.

of collets. While toolrooms and assembly areas are appropriate places to store collet sets, the same can't be said for the production floor, where the sets take up valuable space and normally deteriorate before they are used.

Chucks and vises are perceived as the best method for holding workpieces, but this is not always true. Chucks and vises have a distortion factor called "jaw yaw." By design, the clamped part is held tighter at one area of the jaw—usually the bottom—than it is at the other—usually the top. Clamping forces are usually not produced on the same plane where the force is applied, causing a lever action. This levered clamping action can change significantly over time.

The movable jaw in a vise construction can also ride up. As with chucks, pressure is applied off-center from where the part is being held. Vises can clamp with less pressure at the top and side of the jaw. If there are no design restrictions on the jaw, it moves up. Heel-and-toe construction can help correct this condition. However, stability may be sacrificed over the long run.

Collets' Benefits

With collets, on the other hand, the pressure is applied directly to the surface being held. Loss of pressure due to leverage is minimized.

As collets wear, they seat. Because of this, collet clamping pressure often improves over time.

The influence of centrifugal force is less of a factor with collets. The spindle socket serves as a backup, supporting and restricting outward movement. The pressure angle is positioned perpendicular to the forces being produced. In many cases, speeds up to 20,000 rpm can be reached with unmodified collets.

Self-centering is another characteristic of collet construction. If stock sizes are beyond ideal printed mean specifications, a collet—by design—apportions the excess evenly around the contour of the part. In many cases, this can eliminate machine control compensation and save machine control calculating time.

Collets can compensate for variations in forgings caused by heat and die wear, variations in castings from pattern wear and accumulated tolerances from prior machining operations. Because of these compensations, collets can improve a shop's chip-producing time, machine cycle time

The most common draw collet is the C-type, such as the standard 5C (left) and the special 5C with caulked slots.

and overall efficiency.

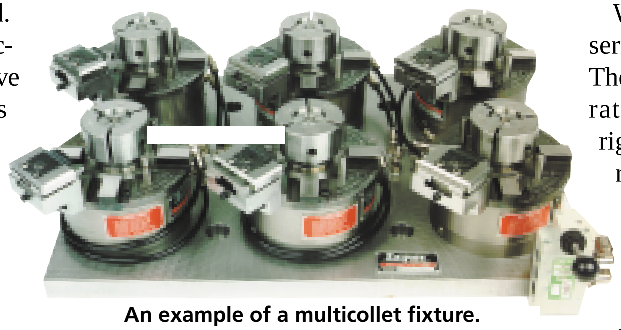
Collets are available for holding on the inside contour of a part, which exposes more of the part's surface to the machining operation.

Some engineers mistakenly believe that part size must be limited when using collets. However, collets as large as 16.00" in diameter are being manufactured daily. When considering ID grip collets, the size of the part can be considerably larger.

If the part being produced has an irregular shape, collets can still be used. With the advances in solid-plunge and wire-type EDMs, many forms can now be burned into a collet. These surfaces provide a high level of gripping force.

Collets can last as long as 3 million grip-cycles with little or no deterioration, but the proper material, heat-treatment and design criteria must be used.

Soft collets and pads are effective for lot sizes as small as five pieces. If the proper material is used, soft collets and pads can be hardened, plated or treated after the initial use is completed.



An example of a multicollet fixture.

Concerns

In some applications, the presence of chips in the collet's expansion slots is a cause for concern. Small chips lodged in the slots can reduce the collet's ability to flex, and their presence can increase maintenance activities. To overcome this problem, fillers can be inserted into the slots. Examples of fillers include caulk, rubber and cardboard. Flushing coolant through the fixture also keeps the slots clean.

The holding force of a collet can be adjusted from very light to very substantial. For example, collets are used in crimping operations during assembly. And they can hold plastics as well as carbon and exotic steels.

Yet the holding force of a collet is dependent on its activating mechanism, or fixturing device that provides the power for the holding force. Fixtures are available with mechanical, pneumatic and hydraulic activating mechanisms. The applied pressure from these mechanisms approaches 360° of contact.

When increased grip is required, serrated collets should be considered. There are many different types of serrations. Some resist both left- and right-hand radial torque, while others reduce slippage caused by pushing or pulling of the workpiece. The basic principle behind serrations is to reduce the contact area, thus increasing the localized pressure in one area.

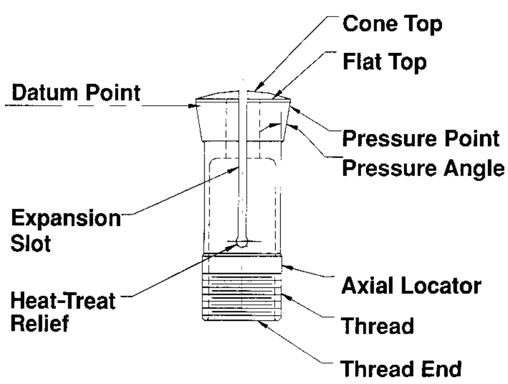
There are also several types of coatings that can augment gripping. Depending on the application, they protect the finish of the workpiece being clamped, reduce slippage and increase surface hardness and/or lubricity. Some examples of these coating are plasma spray, chrome, titanium nitride and electrode etching.

Considering the trend toward smaller and smaller workpieces, it is important to clamp as many parts as possible in the smallest area available, because any excess movement between parts can also add up to lost time and machine wear. As many as eight parts have been successfully clamped with collets at one time within an area measuring 5" in diameter.

The fixture footprint is also important when designing the manufacturing process. If the footprint is big, the machine will wear in only one area. A smaller footprint allows you to move the fixture to more locations on the machine table, thus prolonging machine life.

Collet systems, with related fixtures, are versatile and can be designed into angle plates, tooling columns and interchangeable subplates. A combination of air, hydraulic and mechanical mechanisms used with internal and external gripping can result in a fixture that will expose all sides of a part.

Collets are a well-established technology, but still one whose principles need to be fully understood to maximize productivity.



Characteristics of the collet.

Axial Locator: The diameter at the end of a collet opposite the pressure angle. It aligns the collet on its axis.

Cone and/or Flat Tops: Manufacturing features in the basic design. In a fixed-position application, flat tops can be used for part reference, support and/or locators. Cone tops provide more tool clearance at the collet's nose.

Datum Point: The point on the pressure angle where the angle starts. It is also the point where all other dimensions are referenced. It has a dimensioned point of reference. It is very important to fixed-position collet construction, since it establishes an identifiable reference between multiple collets in the same fixture assembly.

Expansion Slots: The slots in the collet that allow it to flex.

Heat-Treat Relief Holes: These holes control potential cracking during the heat treatment.

Pressure Point: The point on a pressure angle where most of the force is directed and produced. Generally, it is very close to the datum point and located at the larger end of the taper. It is the result of angular tolerancing on the pressure angle.

Thread: The part of the collet that produces a drawing action. In the case of a fixed-position collet, it secures the collet so that a clamping collar can produce the same action.

Thread End: The portion of a collet that sometimes secures the collet in position. Using a jam-nut action against the end of the collet is sometimes preferred to the side-locking screw method, which can cause workpiece distortion.

About the Author

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