WHATEVER YOUR PRODUCT LINE, THERE IS A WORK HOLDING DEVICE TO FIT YOUR PARTICULAR APPLICATION. HERE'S A GUIDED TOUR BY A RECOGNIZED AUTHORITY.

HOLDING THE LINE

By David A. Stokely

As chief designer for Speedgrip Chuck, Inc., I have a fascinating job. I've been involved in the design and building of work holding devices for more than 25 years. There have been lots of changes during that time, and ever-increasing requirements: parts that used to be ground are now turned, formerly turned and machined parts are now cast, higher RPMs, closer tolerances, shorter cycle times, and on and on. But that's what makes this such an interesting and challenging business to be in. Over the years we've designed work holding for a tremendous range of gear applications. One of the most exotic that comes to mind involved a research institution that asked us to design a chuck to hold their part while they rolled the teeth at a red-hot temperature. We have held huge gears for off-road equipment manufacturers, and extremely small gears for dental devices. Creating tooling for hobbing, shaping, broaching, turning, welding, balancing, and the inspecting of gears has kept us very busy for the 60-plus years that we've been in business.

There is an incredible array of mechanisms for the holding of pieces during machining and inspection operations. There might be as many as 15 or more different families of chuck types that we use in solving work holding problems: jaw chucks, clamps of various kinds, single taper collets, double taper collets, split from one end collets, diaphragms, hydraulic sleeve type chucks,

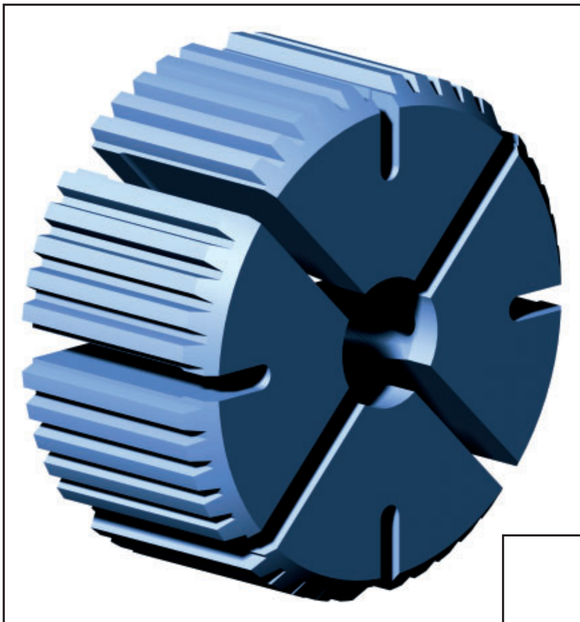
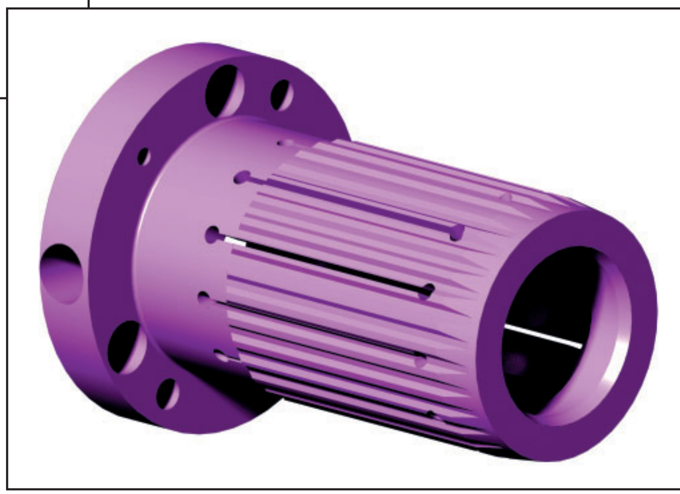


FIGURE 1: Alternately slotted, single taper collet

"THERE IS AN INCREDIBLE ARRAY OF MECHANISMS FOR THE HOLDING OF PIECES DURING MACHINING AND INSPECTION OPERATIONS, WITH 15 OR MORE DIFFERENT FAMILIES OF CHUCK TYPES THAT WE USE IN SOLVING WORK HOLDING PROBLEMS."

FIGURE 2: Hydraulic sleeve



pin chucks, key chucks, push-on collets, torsion collets, and spring loaded taper plugs, just to name a few. We have held everything from hickory handles while the metal rakes and hoes were clamped and riveted on the end, to holding a camera inspecting piles of radioactive waste, to gripping Patriot missile bodies while they are being machined, to lightly gripping syringe barrels while they were being inspected.

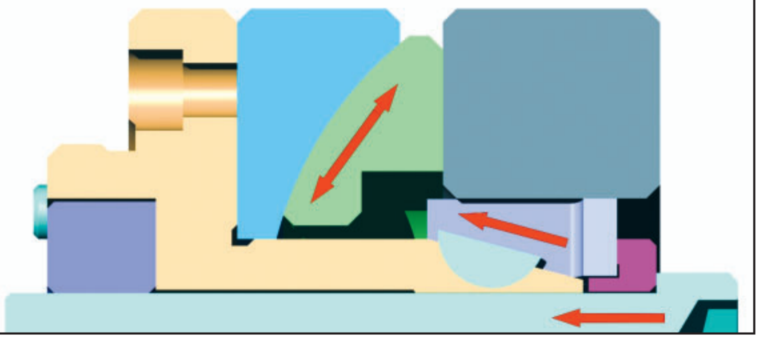
In this article I would like to examine two of the more common chuck types for gear applications: the internal single taper collet chuck, and the internal hydraulic sleeve type chuck. These are two of the real workhorses of second operation chucking. We utilize these designs as often as any other two types of chucks that we manufacture.

Figure 1 shows an alternately slotted, single taper collet. Note that the slots come in from each end of the collet, alternating coming first from the back side and then a slot from the top side. In the far side from the picture there is a female conical taper. The taper angle can range from 5° to 30° depending on the needs of the application, but it is generally in the area of 15° per side. This collet works by sliding the female conical taper up a matching male taper. As this happens, the slots allow the collet to grow in diameter, taking the form of the male taper, till it meets the ID of the part being held. As a result of the collet moving in relation to the part, when the collet OD meets the part ID, the part is pulled down and squared up against the part work stop ring. Typical expansion for this type of collet is roughly 1 percent of the diameter. As an example, if you have a 3.000" diameter you need to grip, a single taper collet of that size would usually have roughly .030" total expansion. There are many things that can increase this, such as collet length, number of slots, material, slot design, but that is a good ballpark number.

Figure 2 shows the hydraulic sleeve. Note that it is also slotted, but the slots do not break out to the ends of the sleeve, they terminate in holes. The actuation takes place by hydraulic fluid contained in a flexible cylinder under the sleeve pushing on the sleeve and bowing the areas between the slots outward until they contact the ID of the part being held. The movement of the sleeve is straight out, so there is no pull back action of this type of chuck. A rule of thumb for a hydraulic sleeve type chuck is .005" expansion for the first inch of diameter and .002" expansion for every inch after that. So again, as an example, if you have a 3.000" diameter part, there would be .005" expansion for the first inch + (2 x .002") for a total of .009" expansion available. Like the collet, lots of things can be done in the design to increase this expansion, but that is a good beginning point.

I have used illustrations of the collet and the hydraulic sleeve with involute splines ground into them for gripping on the pitch diameter. Both types can grip on the minor, pitch, or on the major diameter of the spline. In addition various steps, chamfers, milled

FIGURE 3: Out of square locating face



sections, and EDM forms can be included on both types of mechanisms according to the part requirements.

No one likes to admit it, and nobody wants to talk about it, but everyone has had applications that have driven them crazy. Sometimes you just know when a print comes across your desk that "this one's going to be a doozy." Other times, though, for all the world you expect the job to be a piece of cake, and it turns out to be the one that keeps you awake at night and makes your stomach hurt every time you think about it.

When we are stretching the limits, we expect to have difficulties, but what can we do to avoid problems in the more typical applications? I would like to look at one of the more common challenges that we have seen in making gears. While the examples that I'm using have to do with broached ID splines, the points illustrated are applicable to many different processes and part configurations.

When someone comes to us with a new application for us to review, it is essential that we know everything possible about the part to be held, the machine that the part is being run on, the process that will be performed on the part, and the requirements for the part coming out of the process. I don't know anything about your part or your process or your machine. The information that is sent in with the request for quote is the only thing that we know about the application. I don't know anything about your tool holder, your steady rest, the setting arm, or anything else about your application—unless you tell me. Another thing that I love to hear about, if you are already running the same or a similar part, is how is this part being run now and what features do you like or dislike about the present setup? Give us your wish list: You just might be surprised at what we can do.

One of the first things that need to be determined is where are we going to hold the part. Again, referring to an ID broached part, we have two usual choices. Usually it would be either on the pitch diameter or on the minor diameter. This initial decision carries a number of implications with it.

In almost every instance, it is the pitch diameter that is the datum. So, it makes enormous sense to have that surface to also be your gripping surface, but there are a couple of reasons why people chose to locate on the minor. First of all, whatever work holding device you use, it will be less expensive if you locate on the minor rather than on the pitch diameter. When we are gripping a part on the minor diameter, all we do is take a collet off the shelf and size it to your requirements. Often this can be done in just a few days. Obviously, grinding the teeth into the collet or sleeve OD takes more time and is more expensive than just grinding a smooth diameter. Secondly, loading the part is much easier when you don't have to worry about orientation to the teeth.

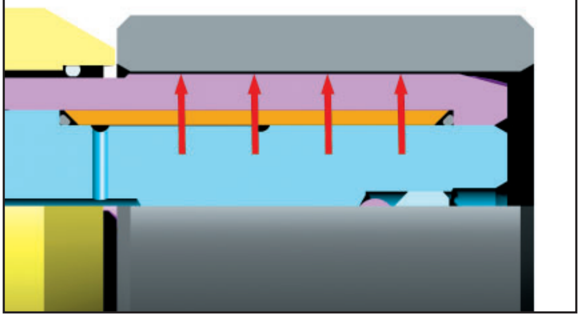
There is one thing that we absolutely never want to do, and that is to machine the part holding on one surface and then have the part inspected holding it on another. That is a recipe for trouble, for you will not know where the source of your error is when you have out-of-tolerance parts.

One of the most crucial pieces of information that we must have is whether the locating face of the part is square to the bore that we are going to be gripping on. This will determine whether we propose a mechanism with pull-down or a dead-length type of chuck. This is not something that you can just assume that you know. Many times that surface is not functionally important, so not much attention is given to it. But for the design of the work holding it is essential that we know how square the locating face is to the gripping diameter.

FIGURE 4: With the pull-down action, the part is centered and squared up on the locating face.

On a number of occasions we have been assured of a square locating face on the part only to find later that the surface was not square after all. The manufacturing engineer had assumed that the face would be square since this was the same surface that the

FIGURE 5: A metal sleeve is deformed under hydraulic pressure to conform to the bore of the part being held.



part was located on for the broaching operation, but we have found that the broach is going to follow the original hole in the part. If that hole was not square to the end face, then the broach will not end up being square to the end face either.

In another instance the parts coming off of the broaching operation were square on a newly sharpened broach, but as the broach wore the part grew more and more out of square. When the broach was sharp we saw squareness values in the range of .0002”-.001”. After much use of the broach, the figures went to between .004”-.005” out of square, resulting in out-of-tolerance parts coming off of the turning operation that we were machining.

Why does an out-of-square locating face cause a problem? A pull-down chuck, as its name implies, pulls the part down against the locating face. This face is actually the primary locating surface. Any unsquareness of that face will override the diameter that we are gripping on. In the case of a pull-down collet, its repeatability is very good. In tests at Speedgrip we have seen that an off the shelf collet, randomly tested, will repeat within .0001”, but look at the mechanism of a single taper collet. When you are gripping in a bore, you have a male taper on the nose, a female taper on the collet, the collet OD and the part ID. Any angular mismatch between the nose and the collet, any taper on the collet OD or taper in the part ID results in there being only line contact between the collet and part, but with the pull-down action the part is centered and squared up on the locating face. (See figure 4)

One solution to this problem is to allow the part locating detail to float in order to have a work support that will compensate for an out-of-square locating face (see figure 3). This technique is commonly used on first operation chucks where we are holding a casting, for example, and it works—but only to a degree. On a first operation chuck no one is likely to be concerned that the turned diameter is a few tenths, or even a few thousandths, out of square with the cast locating surface. In a second operation the uncertainty of the compensating work stop will usually not be acceptable.

If the face of the part is not square to the bore, then we must use a dead-length gripping device. This is one where the gripping detail does not move linearly in relation to the part being held. For dead-length applications we prefer to use a hydraulic sleeve type

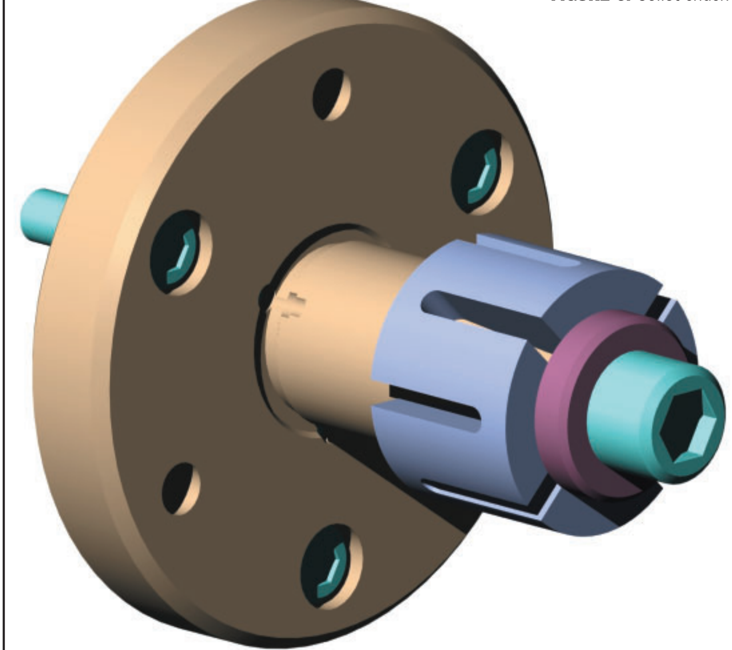


FIGURE 6: Collet chuck

chuck. In this type chuck, as explained above, a metal sleeve is deformed under hydraulic pressure to conform to the bore of the part being held (see figure 5). An out of square locating face in this mechanism will have no influence on the bore, as the sleeve that is doing the holding is taking the shape of the part bore and is therefore not holding the part with line contact. These are very accurate chucks, but they typically do not have as much expansion as a collet chuck. For manually loaded applications this is not very important, but for automatically loaded situations this can be an issue. We have successfully held parts on the pitch diameter that were mechanically loaded with no part orientation. In other words, it is possible to load splined parts with a robot arm, for example, without lining up the teeth or holding a spindle orientation on the machine, but special care needs to be taken during the design process for this to be successful.

Which is the best type of chuck for your application? I strongly urge you to give your work holding supplier the freedom to recommend the best chuck type for your requirements. Here are some of the guidelines that I use when coming up with a work holding solution.

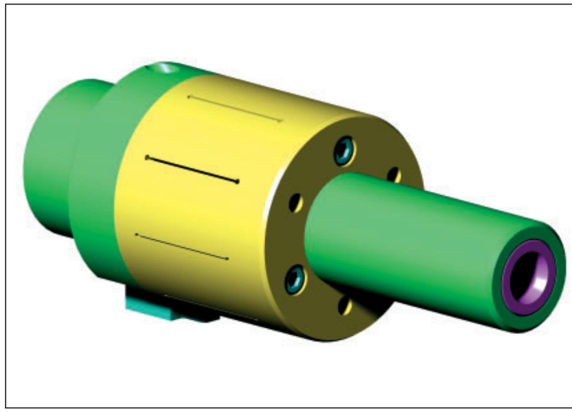


FIGURE 7: Hydraulic sleeve type chuck

Collet chucks (see figure 6) offer good repeatability when there is a locating surface that is perpendicular to the bore is available. They are robust, suitable for untended operation for long periods of time, and are capable of greater amounts of loading part clearance than hydraulic sleeve type chucks. Their operating mechanism is two steel surfaces sliding against one another, therefore wear can be an issue, especially in grinding operations where it is difficult to completely seal out the very fine abrasive particles. The collets are easily replaced. Usually either one or three screws (depending upon the design) need to be removed, the old collet taken off, and the new put on and the screws are replaced. This should only take a very few minutes.

Hydraulic sleeve type chucks (see figure 7) offer the highest concentricity and repeatability without being influenced by the locating surface. If this type of chuck is actuated by a machine drawbar, for example, being a closed hydraulic system, it does require periodic adjustment and maintenance. This type of chuck is totally sealed and has no sliding metal parts, so it is especially well suited for grinding applications. The hydraulic sleeves have less travel than a collet, and so large part diametral tolerances or loading clearance requirements can present a challenge. The sleeves are generally not replaceable on site. Usually these chucks will need to be sent back to the manufacturer for repair or for sleeve replacement. A sometimes-overlooked feature of hydraulic sleeve type chucks is that, due to their few numbers of components, they can offer greater rigidity than almost any other type of work holding design.

This is just a snapshot of some of the issues involved with deciding upon a mechanism for a turning operation on a part with a broached ID spline. I urge you to avail yourself of the experience and knowledge of your work holding supplier. I don't think it is an exaggeration to say that in a month we see more work holding applications than an average manufacturing engineer might typically see in a year or more. We are a resource that should be utilized to its fullest.

ABOUT THE AUTHOR:

David A. Stokely is chief designer for Speedgrip Chuck, Inc. He can be reached at (574) 294-1506 or dstokely@speedgrip.com. The company's Web site is [www.speedgrip.com].