Shaft Coupling

A special case of fasteners is the shaft coupling. A shaft coupling involves connecting a piece which is to rotate onto a shaft. The piece may be a drive gear, a lever arm, a cam, etc.

The easiest method for shaft coupling (and the most unreliable, of course) is to use a set screw. Set screws are effective in low loading conditions only.

At the expense of additional manufacturing time, a key way can be cut into the shaft and broached into the mating piece. A key fits into the mating grooves and provides the power transfer. It is a good idea to put a set screw on top of the key to hold it in place.

The mating piece can be press fit onto the shaft. Sometimes the shaft is knurled to accommodate the press fit. This is suitable only in lightly loaded situations, as the press fit can slip. Pressing is not a good choice if the item has to be removed frequently.

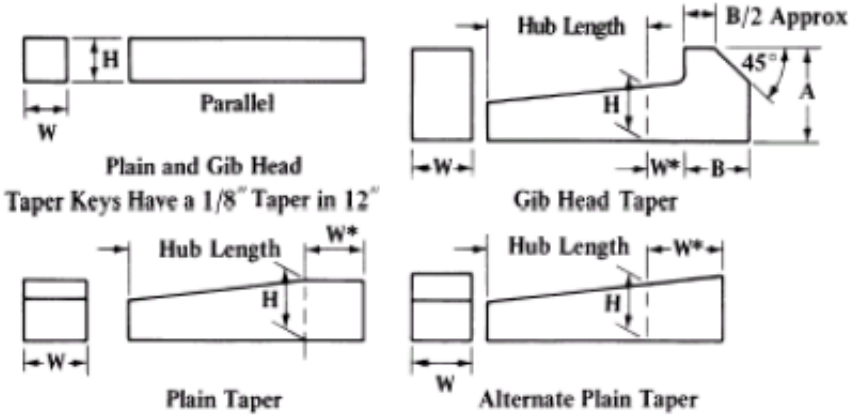
Spline shafts are perhaps the best method for shaft coupling. They require more manufacturing time and therefore may be more expensive.

Square and hex shaft may be used to provide coupling. The external square or hex is machined onto the shaft. The mating piece has a square or hex hole.

Pinning the two pieces together is another alternative for shaft coupling.

Square and Woodruff Keys

Types of keys include parallel, tapered, gib head taper, and alternate taper.



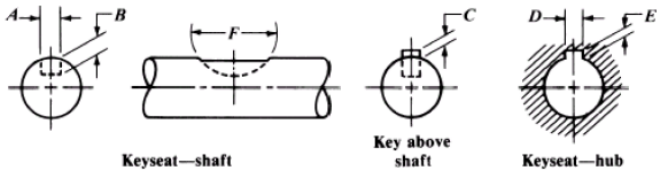
A table indicating recommended key size versus shaft diameter is presented on the 26th Edition of Machinery's Handbook on pg. 2343.

It is recommended that the key way on the shaft be cut no more
than .01" over-sized. Some over-size is necessary to allow the key to be placed easily into the shaft, otherwise, you end up with a press fit.

I typically use about .002-.005".

Woodruff keys have a half-moon shape. The key seat in the shaft is cut using a
Woodruff key cutter and has a semicircular section. The key way in the mating piece has a standard key form.

We have used both square and Woodruff keys in projects at UALR. I prefer the square key. I suspect that the Woodruff key induces smaller stresses in the shaft.



Machining Key Seats

A square key way is machined into a shaft by milling. Usually, a bit the size of the key is used and a polishing pass (.002-.005” larger than the key) is taken to clean up the back side of the key way. Special key way cutters are available.

A Woodruff key cutter (each standard type of Woodruff key has its own cutter) is used to cut a Woodruff key way.

This cutter is brought into contact with the shaft and cuts through to the specified depth.

The key seat in the mating part is made by broaching.

A set of broaches is a special set of saws which, when pressed through a piece of material, gradually cut away a square half-hole.

One advantage of keys as a shaft coupler is that failure can be designed into the key. In other words, the shearing stress required to fail the key can be calculated. As long as this failure occurs before failure in the key seat or the shaft or any other part, then the key protects the rest of the system from failure.

An example of this design feature occurs in the lawn mower drive shaft. If a blade hits a stump, then the key is designed to fail before the mounting bolts, the blades, or the drive shaft itself.

A $.25 key can protect a $1000 system.

Press Fit

A press fit involves pushing a larger diameter piece into a smaller diameter hole. Consult with Machinery's Handbook for press fit values. (We covered press fits by shaft diameter in Advanced CAD last semester, so you might consult your notes on that section.)

If a very heavy press fit is desired, either the hole can be heated, causing expansion or the shaft can be cooled, causing contraction.

The down-side to a press fit is that both parts must be precisely machined, the fit is "permanent," and only friction is holding the two parts together.

Pinning

Pinning involves drilling/reaming a hole into both the shaft and the mating piece.

A dowel pin or spring pin is press fit into the two holes.

This kind of press fit is a good thing, as the forces to remove the press fit are very small. The drive forces are perpendicular to the pin.

To remove the pin, a pin driver or punch is used. Therefore, drill through both sides of the mating piece. Otherwise, the pin will be in for good.

Pins may fail in shear. As with keys, this provides a means of protecting more expensive parts in the system.

As an example, the shear pin in the lathe lead screw drive system is designed to fail if the cross feed is crashed against a stop. It is a 2 minute job to fix this type of failure (punch out the old pin, drive in the new pin.) The other place for failure would occur in the lead screw, a disastrously expensive fix!

Shaft Couplers

A final method for joining a shaft to a mating element is to use a shaft coupler.

Shaft couplers come in a variety of forms. The basic concept is to surround the shaft with a material which can be made to grab the shaft. In other words, some mechanical advantage (such as a screw) is used to create a large normal force around the circumference of the shaft.

This normal force creates a friction force, which is tangent to the circumference. The friction force keeps the shaft and shaft coupler in a no slip condition.

One example of a shaft coupler is the Trantorque. This coupler is designed to have a shaft pass through it and a hub pass around it. When a nut is tightened, an inner surface grips the shaft and an outer surface grips the hub.

Other features to the shaft coupler include the ability to account for misalignment. In the extreme, the shaft coupler would include a universal joint, which can account for three dimensional misalignment between mating shafts.

Rather than show many possible examples of shaft couplers, I would advise that the interested student go to different parts sellers, such as Small Parts, Stock Drive Products, PIC Design, or McMaster Carr and see what actual couplers are available.

Square and Hexagonal Shafts and Broaching

Another method of coupling a shaft to a part is to use either square shaft or hexagonal shaft.

The only problem is that the accompanying hole must be either square or hexagonal.

There are a couple of processes by which a square or hexagonal hole can be made.
The easy way (if the hole goes all the way through the part) is to make a round hole and then broach it.

A broach is a cutting tool which removes an increasingly large amount of material as it is pushed through the part.

A press (in many cases an arbor press) is used to push the broach through the hole.

Square and hexagonal shafting is available almost as commonly as round stock.

The down-side to this method of shaft coupling is that the dimension of the shaft and hole will not be precisely coupled, so some slop is introduced.

Spline shafts are also available (similar to square and hex).