Perfect Mortise-and-Tenon Joints

A plunge router, a tablesaw, and a couple of jigs make the process almost foolproof

BY JEFF MILLER

The mortise-and-tenon joint is one of the strongest woodworking joints. For maximum strength, a mortise-and-tenon joint needs good contact between long-grain surfaces; those are the surfaces on the sides of the mortise and the cheeks of the tenon. That means the long-grain surfaces must be flat, smooth, and parallel. And, just as important, the fit between those surfaces must be snug.

My techniques for cutting mortise-and-tenons have served me well for years. The mortises are cut with a plunge router, a straight bit, an edge guide, and a shop-made jig. Tenons are cut on the tablesaw with a tenoning jig. The machine work generally produces a fit that's right on. If it isn't, the final fitting is done with a few hand tools. All of the techniques are simple and efficient, and they result in perfect-fitting joints.

How snug is snug?

A snug fit allows for a very thin layer of glue (0.002 in. to 0.004 in.) between the contact surfaces once the joint has been assembled. If the fit is too tight, as the tenon is slipped into the mortise, almost all of the glue ends up squeezed to the bottom of the mortise, resulting in a glue-starved joint—one that has little strength. Too loose

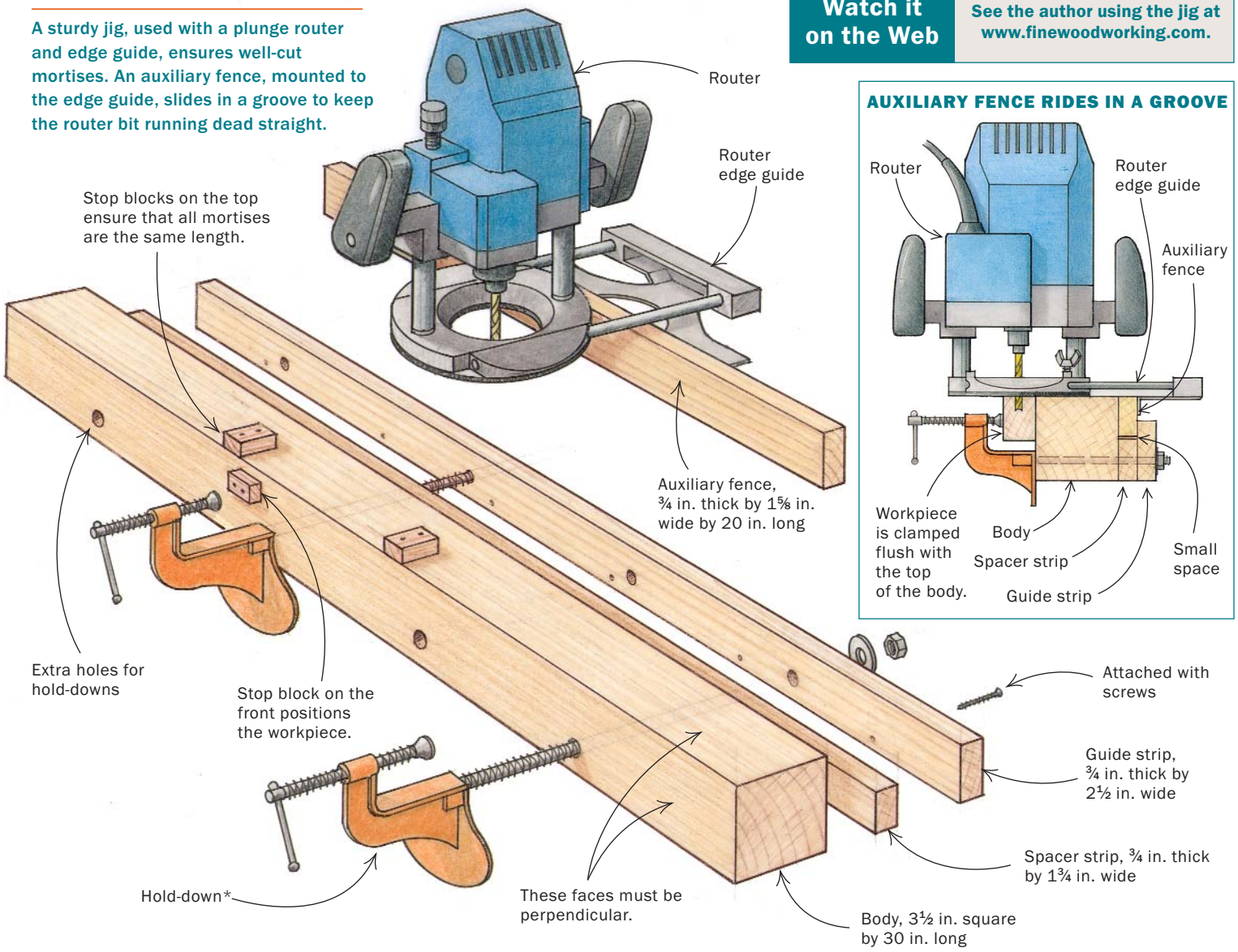
Photo, this page: Kelly J. Dunton

A SIMPLE MORTISING JIG

A sturdy jig, used with a plunge router and edge guide, ensures well-cut mortises. An auxiliary fence, mounted to the edge guide, slides in a groove to keep the router bit running dead straight.

Watch it on the Web

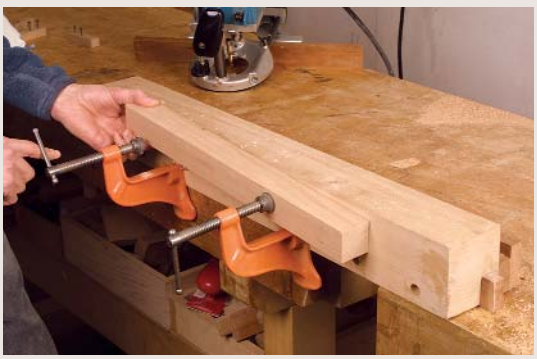
See the author using the jig at www.finewoodworking.com.



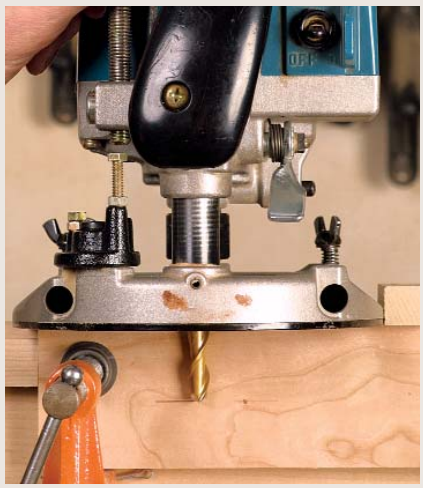
AUXILIARY FENCE RIDES IN A GROOVE

CUT MORTISES FIRST

Once the jig is made, it takes little time to rout a mortise. A standard straight bit works just fine, although a spiral upcut bit does a better job clearing chips from the mortise.



Clamp the workpiece to the mortising jig. *A pair of sturdy hold-downs anchors the workpiece to the jig.*



Set the bit depth. *With the desired mortise depth marked on the workpiece, adjust the bit depth on the router.*

Center the bit. *After marking the location of the mortise, adjust the edge guide to center the bit in the mortise.*

Drawings: Vince Babak

a fit, and there isn't enough surface contact for a good glue bond.

A joint is too tight if a mallet or clamp is needed to put it together. It's too loose if it goes together with little or no resistance. A joint that's just right goes together by hand with only a moderate amount of pushing and wiggling.

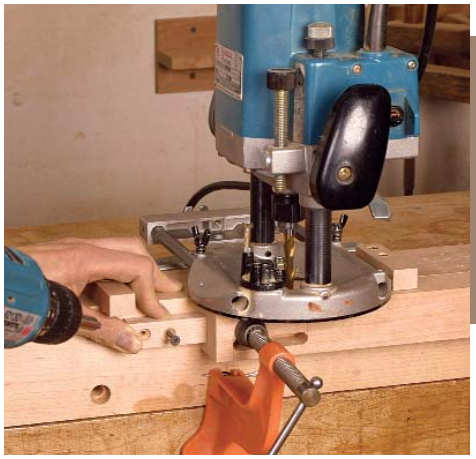
One more point here: The end of the tenon shouldn't extend to the bottom of the mortise. To allow room for excess glue, cut the tenon about 1/32 in. shorter than the depth of the mortise.

Keep in mind, though, that it's difficult to get perfect-fitting mortise-and-tenons if the stock isn't properly prepared. So make sure the moisture content isn't too high or low. And be sure to mill all of the parts on a jointer and thickness planer, or by hand, until each workpiece ends up flat, straight, and square.

Cut the mortises first

In general, it's best to cut the mortises first and then cut the tenons to fit the mortises. First, though, you need to get a few things together, and you need to make a jig.

Use a plunge router and a straight bit—A plunge router, rather than a fixed-base router, is pretty much a must to cut mortises. Any effort to tip the bit of a fixed-base router into a workpiece to create a mortise is not only dangerous, but it's also likely to produce an inaccurate cut. A mid-size (1½ hp to 2½ hp) plunger is sufficient, as this technique creates mortises by making lots of light cuts.



A stop block for multiple mortises

When several identical workpieces require mortises, Miller adds a stop block to the front of the mortising jig (facing page), allowing him to position each piece quickly.

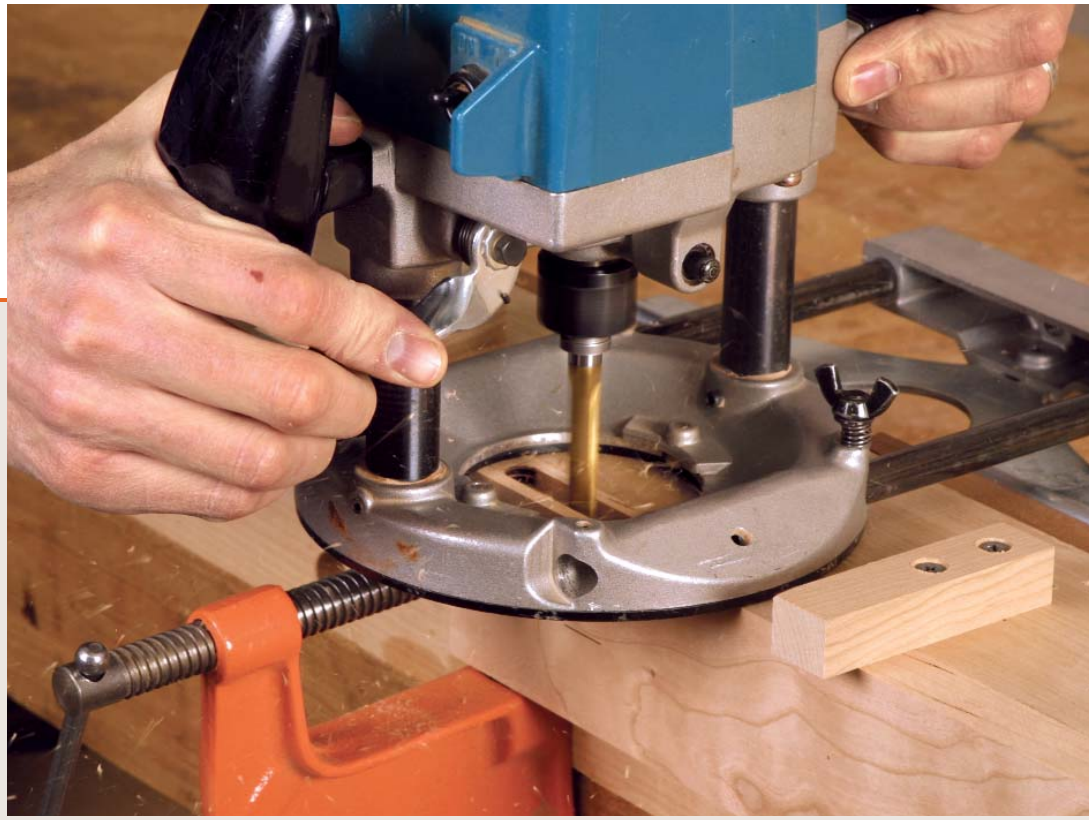
The diameter of the router bit determines the width of the mortise. For example, a ¼-in.-wide mortise is cut with a ¼-in.-dia. bit; and a ¾-in.-wide mortise is cut with a ¾-in.-dia. bit. You also could choose a mortise width that requires moving the router over and taking extra passes to widen the opening. But because straight bits are available in so many sizes, you can usually find one to match the mortise width you need.

Make a jig to guide the router—It's important to support and guide the plunge router as it cuts. A jig goes a long way toward providing the necessary support, ensuring a well-cut mortise. The jig I use is very simple (see the drawing on the facing page), with just three wooden parts: a body, a spacer strip, and a guide strip.

A pair of hold-downs made by The Adjustable Clamp Co., style No. 1600 (312-666-0640; www.adjustableclamp.com), are used to secure the workpiece to the body.* With the hold-downs in place, the jig accepts stock up to about 2¾ in. wide. To work with wider stock, simply remove the hold-downs and secure the workpiece with a couple of C-clamps.

You'll also need to make a wooden auxiliary fence to attach to the edge guide of the router. The auxiliary fence offers two benefits. It increases the length of the edge guide, providing extra support during a cut. And

Stop blocks establish the mortise length. *Stop blocks on each side of the router base limit the travel of the base.*

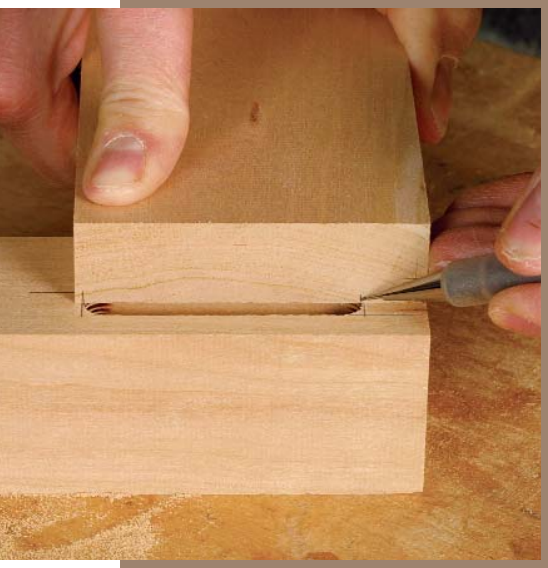


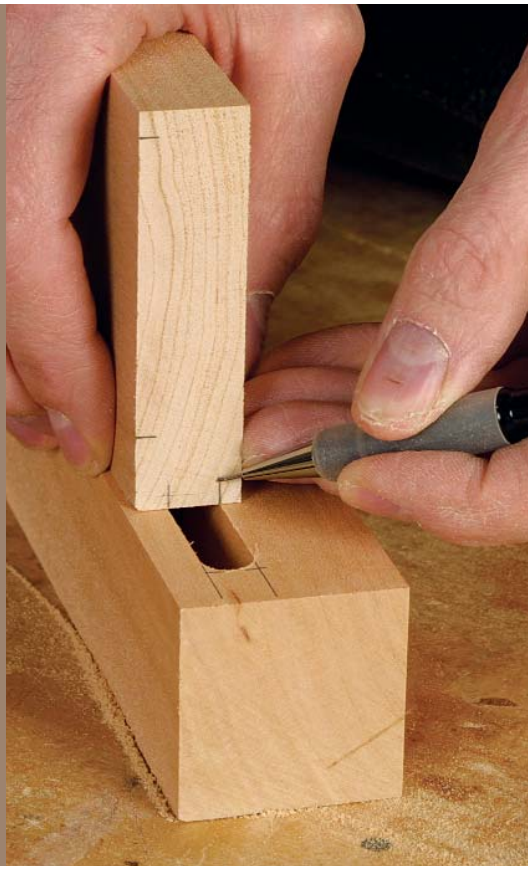
Take light cuts until you reach the final depth. *To produce smooth, straight-sided mortises, make multiple passes with the router, with each pass removing no more than 1/32 in. of stock.*

Photos, except where noted: Tom Begnal

Use the mortise to lay out the tenon

Butt the end of the piece to be tenoned against the mortise, then mark the tenon length (left) and thickness (right).





because the auxiliary fence fits into a groove created by the spacer and guide strips, it prevents the edge guide from shifting away from the body, and that means the router can't wander from a straight-line cut.

In use, the fence slides back and forth in the groove. The clearance between the fence and the groove should be no more than the thickness of a sheet of paper. To help the parts slide easily, I like to add a thin coat of wax to both the groove and the auxiliary fence.

Using the jig to cut mortises—Once the initial setup has been completed, it takes just a few moments to create each mortise. Start by laying out the location of the mortise on the workpiece. Then clamp the workpiece to the body of the jig. Make sure the top surface of the workpiece is flush with the top of the jig.

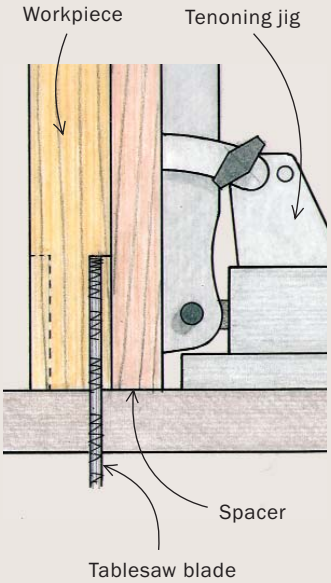
Adjust the plunge-router depth stop to establish the final depth of cut. Next, place the router on the body of the jig, with the auxiliary fence of the edge guide in the groove. Now adjust the edge guide until the router bit is centered in the mortise.

CUT TENONS LAST

1 INSERT THE SPACER

Spacer makes tenons of uniform thickness. *The spacer should be a hair thinner than the width of the mortise plus the width of the sawkerf.*

2 CUT THE FIRST CHEEK



Clamp the spacer in the jig and against the scrap stock in back. *Adjust the jig to line up with the tenon mark, then cut the first cheek.*

Next, screw two stop blocks to the top of the jig, one on each side of the router base. The stop blocks help save time and improve accuracy, even when cutting just one mortise. Position the blocks so that the bit stops when it reaches each end of the mortise.

When cutting mortises in more than one workpiece, add a stop block to the front of the jig. Locate the block so that when the workpiece butts up to it, the mortise is positioned exactly where it needs to be relative to the two upper blocks.

Now you're ready to start cutting. Try not to remove more than 1/32 in. of stock per pass. That's the secret to a well-cut mortise. Cuts deeper than 1/16 in. sometimes can cause the bit to deflect slightly, which can produce a mortise with rough sides. Also, the sides are less likely to be perfectly straight or flat. Deflection also can make the mortise slightly wider than the bit diameter.

As you cut, move the router smoothly back and forth, using the stops to limit the mortise length. After each pass, lower the bit another 1/32 in., then engage the plunge lock and cut again. Continue cutting and lowering until you reach the depth-stop setting that represents the full mortise depth. Although it requires lots of passes, the process is surprisingly quick. It takes some practice to get comfortable with this technique, but the mortises that result make it well worth the extra time and effort.

Cut tenons to fit the mortises

With the mortises cut, you can start working on the tenons. Once again, you'll need the aid of a jig. But this time, all of the hard work is done using a tablesaw rather than a router. The tenoning jig supports the workpiece as it passes vertically over the blade, helping to create a pair of cheek cuts that are flat, straight, smooth, and parallel.

Almost any sturdy tablesaw tenoning jig will work, as long as the guide bar is snug in the miter-gauge slot. A sloppy fit can affect accuracy. Also, the jig must hold the stock perpendicular to the saw table in two planes: front to back and left to right.

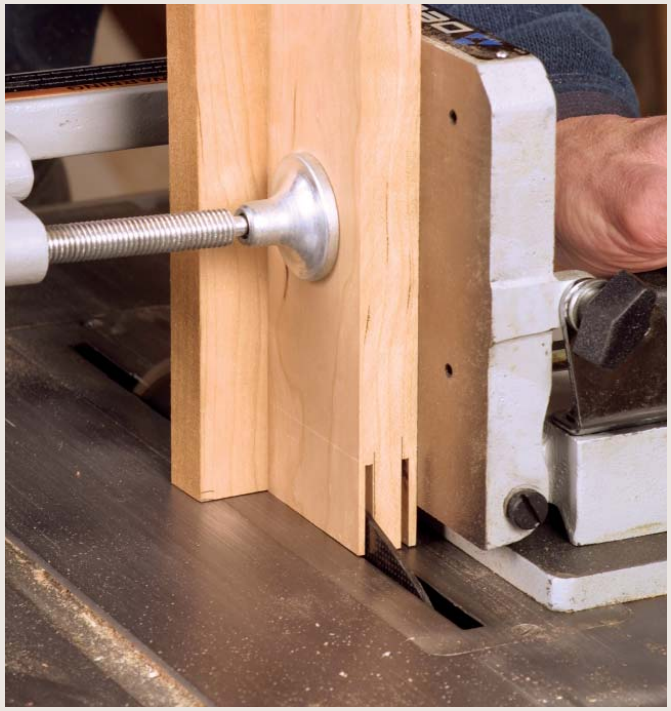
A general-purpose blade works fine here. But it must be sharp. Keep in mind, though, that even a sharp blade forced to work too hard is likely to deflect and produce tenon faces that are not parallel. So don't feed the stock too aggressively. To help prevent tearout, back up the workpiece with a piece of scrap stock (see the photo for step 3 below).

Key to this system is a shopmade wooden spacer that's used with the tenoning jig. The spacer is sized so that the thickness of the tenon is established in just two cuts: one with the spacer in place and one with it removed. The spacer automatically creates the tenon thickness you want, no matter where the tenon is positioned on the end of the board. Also, because you always reference off the same side of the workpiece, the spacer prevents any variation in the thickness of the workpiece from affecting the size of the tenon.

The thickness of the spacer should be a hair less than the width of the mortise plus the width of the sawblade kerf. A dial caliper proves handy here.

I usually do the initial setup of the tenoning jig using a throwaway test piece that matches the thickness of the workpiece. To avoid confusion, mark one face of each workpiece as the working face. That way,

3 REMOVE THE SPACER AND CUT THE SECOND CHEEK



Spacer-free second cut. *After making the first cheek cut, remove the spacer and slide over the workpiece to clamp it directly against the jig.*

4 CUT THE TENON SHOULDERS

Use the miter gauge and a stop block. *For consistent tenon shoulders, clamp the stop block to the rip fence and make the shoulder cuts using a miter gauge.*

Fine-tune the tenons for a perfect fit

The edges of the tenon are rounded over with a rasp to match the rounded ends of the mortise (top). A tenon slipping into a mortise sometimes can squeegee glue from the mating surfaces; applying a light chamfer all around the end of each tenon minimizes the problem and helps ensure a strong joint (center). A perfectly fitted tenon will slide in with only moderate hand pressure and not fully slip out of its mortise when held upright (bottom).

you can orient each piece correctly as you insert it in the jig.

Next, use one of the mortises to mark the tenon on the test piece. Once marked, add the spacer to the jig, then clamp the test piece, making sure the working face is against the spacer. Raise the blade to equal the tenon length. Adjust the tenoning jig as needed to make a cut at the marked line. Now, make the cut in a single, smooth pass.

After the first cut, remove the spacer and reclamp the workpiece with the working face against the jig. Then make the second cheek cut.

The shoulder cuts are made with the miter gauge. Set the blade height to cut just shy of the tenon cheek. You might have to change the height of the sawblade for each tenon cheek if the tenon isn't centered on the workpiece. Clamp a stop block to the rip fence to establish the distance from the end of the tenon to the shoulder cut.

The miter gauge also is used to make the shoulder cuts on each edge of the tenon. I then use a chisel or a tenon saw to make the two vertical cuts that establish the final width of the tenon.

At this point, the tenon is squared, while the mortise is rounded. Although you can use a chisel to square the mortise corners to match the tenon, it is much easier to round the tenon corners with a rasp. The last thing I do is apply a light (1/32-in.) chamfer all around the end of the tenon.

Make adjustments to get a perfect fit

Cutting a mortise-and-tenon includes many variables, ranging from the grain of the wood to the accuracy of measurements to the sharpness of the cutting tools. So despite all of my best efforts, I sometimes end up with a joint that doesn't fit as well as I'd like. When that happens, a little hand-tool work soon has the joint fitting just right.

A tenon that's too fat can be thinned in a number of ways. The best approach often depends on how much material has to be removed. It's best to avoid going back to the tenoning jig at this point because, when making trimming cuts, all of the cutting force is on one side of the blade, and that can cause the blade to deflect slightly. If the blade deflects, you end up with a tenon that's slightly tapered.

Machinist's vise can help sometimes— A joint that fits together, but only after the

Three ways to trim a fat tenon

Pressure from a vise sometimes can thin a slightly thick tenon just enough to fit comfortably in a mortise (left). A shoulder plane can do a good job shaving small amounts of material from the cheek of a tenon (center). A router plane is an effective cutter. In use, the sole of a router plane bears on the face surface of the workpiece, so the tenon is just about certain to end up flat and parallel (right).

parts have been subjected to lots of difficult pushing and wiggling, needs only a slight adjustment. When that's the case, I'm often able to create a perfect fit simply by squeezing the cheeks of the tenon in a heavy-duty machinist's vise. This can take a lot of force if the tenon has some size.

Rasps or sandpaper work, too, but use care—A joint that can't be fully fitted together is going to need more than a simple vise squeeze to produce a good fit. It means some material has to be removed from the tenon cheeks.

A rasp can do the job. So, too, can a piece of sandpaper glued to a flat block of wood. However, both of these methods have pitfalls. In particular, unless you're very careful, the cheeks are likely to end up rounded over slightly. Also, it's difficult for rasps and sandpaper to get into the corner of the shoulder and the cheek.

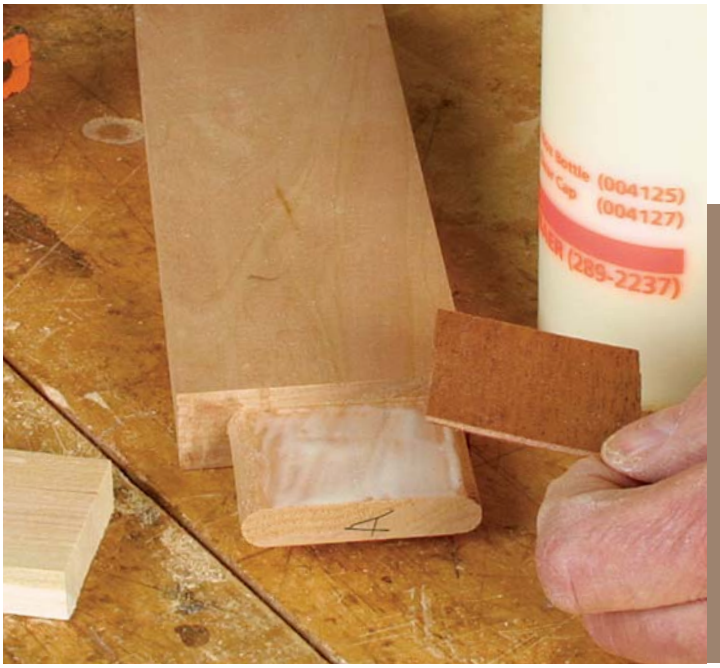
Handplanes are the best option—One of the most effective tools for thinning tenons is the shoulder plane (also called a cheek plane or rabbet plane). It's a unique tool that can cut right up to the shoulder of the tenon.

When cutting with a shoulder plane, remove an equal amount of material across the full width of the tenon. Before getting the hang of the tool, it's not uncommon to have little, if any, material removed at the beginning of a cut, and too much material removed at the end of the cut.

Another good tool for shaving the cheeks of a tenon is the router plane. I like the tool because, as it cuts, the base of the plane rides on the face of the workpiece. That means the cheeks are going to remain flat and parallel to the workpiece faces. But it takes some practice to get comfortable with the blade-adjustment process, and the plane typically needs a lot of tuning.

Tenons aren't always too thick after they come off the tablesaw; sometimes they end up a bit too thin. When that happens, the joint usually can be salvaged by gluing a patch of wood to one or both cheeks. If necessary, plane the cheek perfectly flat before adding the patch. The patch should be thicker than what's needed, so you can plane down the patch for the perfect fit. □

Jeff Miller builds furniture in his Chicago shop (www.furnituremaking.com). He also teaches and writes about woodworking.



Shim a tenon that's too thin

A tenon that ends up a little too thin can be thickened by gluing a slim piece of stock to a cheek.

***Correction/clarification:** This article specified a pair of hold-down clamps from the Adjustable Clamp Co. Each clamp includes a ⅜ in. threaded rod that measures about 3 ¾ in. long. In the text, however, we failed to mention that the threaded rod as supplied was too short for the jig, the 3 ¾ in. threaded rod was replaced with one that was 6 ½ in. long. Also, you need to epoxy a nut on one end of the rod so that it can slip into a notch in the clamp (not shown in the illustration).