

End Mills

End mills come in all shapes and sizes with a number of kinds of coatings. You want to make sure you order the right one for your job taking into account your material and your design.

Common Types

Flat or Square End



Flat end mills are perfectly suited for flat surface and pocket cuts. They are also preferable for contour cutouts because they do less damage to the sacrificial layer on the mill bed. These end mills have end-cutting teeth, allowing the tool to cut vertically along its axis as well as radially. This makes them suitable for drilling, spot facing and counter-boring and for jobs that require drilling or plunge cutting to start a cut.

Ball End



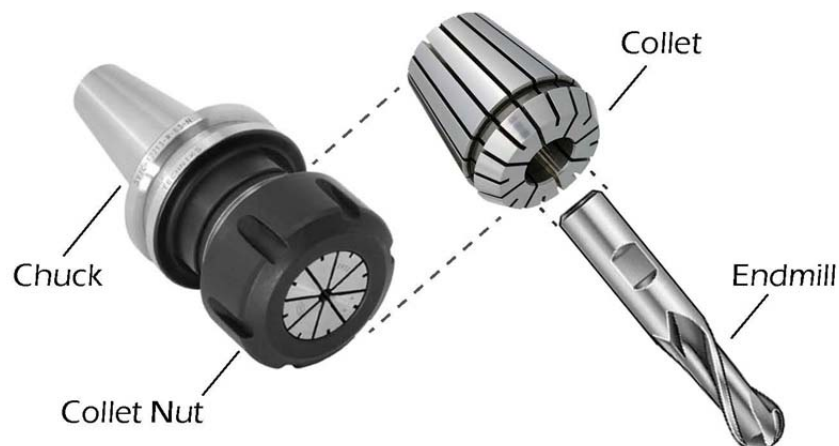
Ball end mills, also called ball nose, are preferable for milling contoured surfaces. They should also be used for cuts that require a rounded detail, such as a slot with rounded bottom.

Dovetail

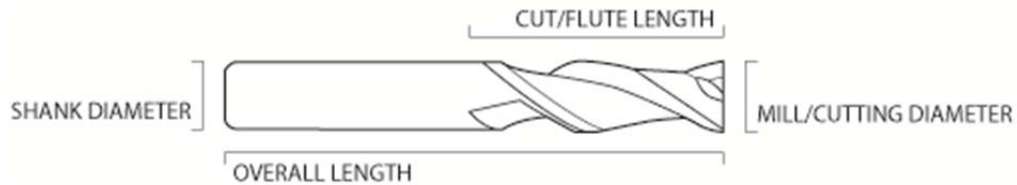


Dovetail end mills are just one of the many types of shapes you can buy to get a distinct side profile on your piece. They must enter the stock from the side (or in an appropriately sized hole).

The Chuck



Dimensions



Cutting Diameter

Smaller end mills allow for more detailed cuts, but they tend to break easily and require a small stepdown. Larger end mills can remove more material and cut faster. It is wise to use a larger end mill, like one with a $\frac{1}{2}$ " cutting diameter, for rough cuts, and a smaller endmill, $\frac{1}{4}$ " or smaller, for finish cuts.

Shank Diameter

The shank diameter can be the same as the cutting diameter, or it can be different. End mills should be ordered with shank diameters to fit one of the collet sizes we have: $\frac{1}{2}$ ", $\frac{3}{8}$ ", $\frac{1}{4}$ ", and $\frac{1}{8}$ ".

Cut Length

The cut length of your end mill is crucial. Determine the length of your cut and order an end mill longer than the maximum depth of your cut. If you are cutting through 2" blue foam all in one pass, you should buy end mills with a 2" cut diameter. If you are cutting through 2" of hard wood and are using a step down, your end mill should have a cutting length greater than your step down, but probably does not need to be 2".

Overall Length

The overall length of your end mill should be greater than your stock height. This allows you enough length to set it into the collet and be able to cut all the way through without the chuck running into your material. (This will clearly cause major problems!)

Flutes

Number

Commonly the number of flutes ranges from two to four. Most milling done in our lab requires no more than two flutes, however you should be aware of the following information:

Fewer flutes allow for more chip removal, which keeps end mills cooler.

More flutes can be fed at a greater rate and generally create a finer finish.

Two flute end mills are center-cutting. When used as a drilling tool, these best maintain the hole size and location because one of the flutes crosses the end center of the end mill.

Helix

The flutes of an end mill form a helix around its axis. The helix has several variables that are worth mentioning:

- **Up-Cut:** Up-cut helices eject chips upward, resulting in a smooth bottom of the material. These tools are not recommended for milling laminated woods because they tend to cause fraying on the top surface.
- **Down-Cut:** Down-cut end mills push chips downward, producing a smoother top of the material. They are also good tools for contouring and cutting pieces out. **DO NOT USE for drilling!!! They will cause fire!!!**
- **Compression-Cut:** Compression-cut end mills have a helix that changes direction. The majority of the compression-cutter helix is down-cutting, while a small section at the end is up-cutting. This results in a smooth surface on both the top and bottom, which is perfect for laminated woods. This type of end mill creates a superior finish, but they cost significantly more than up-cut or down-cut types.

Coatings

Coatings can lengthen the life of an end mill, but is really only critical for what we do for certain materials. Acrylic (and metals) requires a coating to prevent the material from bonding to the flutes of the end mill. See the chart below for recommended coatings:

Wood	Foam	Plastic	Nonferrous Metal	Metal
None	None	TiCN	TiCN	TiAlN

Titanium Carbonitride (TiCN)

Blue/Gray in color, this coating is 30% harder than TiN coatings and is the optimum choice for tool life in long production runs. TiCN end mills operate at aggressive feeds and speeds and are excellent for abrasive or difficult to machine materials.

Titanium Aluminum Nitride (TiAlN)

Dark gray color, this advanced coating is available on carbide end mills and can take the heat and thermal stresses that occurs in milling heat-treated and exotic materials. This coating allows use in dry milling applications and saves on coolant costs. TiAlN is the first choice for milling stainless and high-temp alloys as well as titanium. This coating is also used for high speed machining (HSM) applications.

Where to Buy

[McMaster-Carr](#)

McMaster has a good selection of inexpensive end mills. Unfortunately, you cannot specify the helix direction through McMaster. You can order directly from McMaster and orders are delivered next day.

[Onsrud](#)

Onsrud has a great selection of specialty end mills. You can choose your end mill type on the Onsrud website, but they must be ordered through a vendor.

What to Buy

Depending on what you are cutting and the height of your stock, you will want to take a look through the McMaster-Carr website for your choices and prices. But here is a set that will take care of much of what you are trying to do with a normal step down. All numbers are for McMaster and are thus, all down cutters.

3051A18	1/2" Cutting Diameter Square/Flat End Mill with a 1" Cutting Length High Speed Steel, 1/2" Shank Diameter, 3" Overall Length	\$12.96
3046A17	1/2" Cutting Diameter Ball End Mill with a 1" Cutting Length High Speed Steel, 1/2" Shank Diameter, 3" Overall Length	\$20.90
8876A63	1/4" Cutting Diameter Square/Flat End Mill with a 1-1/8" Cutting Length Solid Carbide, 1/4" Shank Diameter, 3" Overall Length	\$16.26
8878A64	1/4" Cutting Diameter Ball End Mill with a 1-1/8" Cutting Length Solid Carbide, 1/4" Shank Diameter, 3" Overall Length	\$21.08