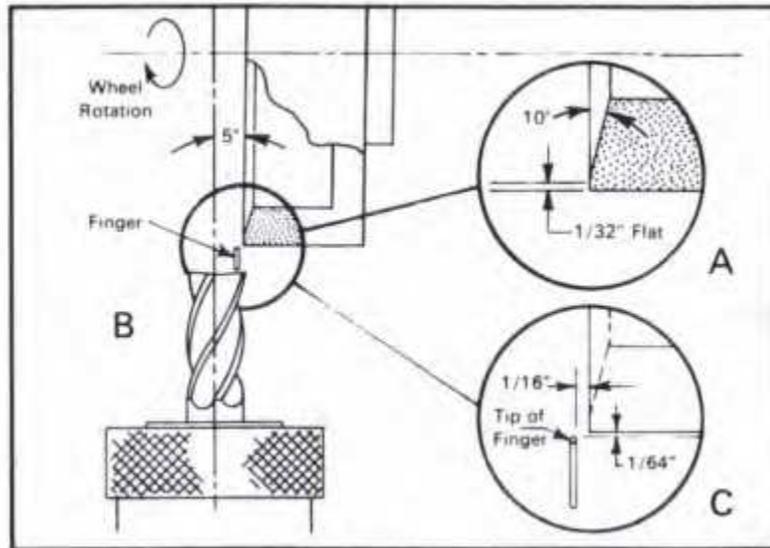


## END MILL SHARPENING

### Sharpening the flutes of the end mill

The flutes of the end mill can be ground by more than one method. I believe the method used is a matter of preference, they are both good. Some grind the flutes on the periphery of the grinding wheel, but I prefer to grind the flutes using the face of the wheel and this article addresses that method. Either type of cup wheel ( straight or flared ) , can be used.



End mill, Finger, and Grinding wheel relationship

The above image shows the relationship between the end mill, the finger rest, and the grinding wheel. The image shows a straight cup wheel, but the same principal applies to the flared cup wheel. The wheel is dressed with a 10 degree angle inward on the face leaving a 1/32" flat area at the outer edge. The finger tool rest is placed about 1/16" in front of the wheel and about 1/64" away from the outer edge of the wheel. This position is such that when drawing the flute across the grinding wheel, The end mill will be clear of the wheel before dropping off the finger. The grinding head is pivoted 5 degrees as in the above image. This makes only the outer edge of the grinding wheel contacting the flute of the end mill. The center height of the grinding head is set to the same height as the center of the spindle axis of the end mill holder. The wheel rotation will be clockwise. There is discussion about the wheel direction and the edge finish of the grind. The clockwise rotation tends to help keep the flute against the finger. The primary and secondary angles of the flute are selected from the chart on the grinder for the proper diameter end mill. The grinding head is to be adjusted to this angle. Adjust the stop ring on the rear of the air bearing such that the end of travel is just at the end of the flute at the shank end. You are now ready to grind the flute. ( A tip here is to use a felt tip marker and color the flutes in the area to be ground so it is easy to see the new grind.)

To grind the flute, position the air spindle until the rear stop ring is against the housing. Adjust the Y axis feed in until the end mill barely touches the wheel and sparks. Tilt the air bearing away from the wheel, move the Y axis in .002". tilt the air bearing into the wheel and draw the flute across the wheel at a slow even pace until it reaches the end of the travel and drops off the finger. Slight hand pressure turning to the right will keep the flute against the finger as well as the downward force of the wheel helps here also.

Inspect the grind by pulling the spindle back and rotating it to inspect the grind, however , DO NOT remove the end mil from the holder until all the grinding is completed.

Turn the spindle to the next flute and repeat this process until all flutes are ground. If needed advance the Y axis .002" more and grind all flutes again. This process is repeated until all flutes are satisfactory. The secondary angle only need be ground if the lands are to wide on the primary grind. If the secondary angle needs ground, the head is tilted to the proper angle from the chart and the process is repeated. The land width on the flutes will be usually from .015" to .030" depending on the end mill diameter.

Below is a photo of the grinding guide which is found on the tool grinder. It gives the primary and secondary angles of various tool diameters as well as the primary and secondary angle for the end of the tool.

END MILL SHARPENING CHART												
CUTTER DIA.	PRIMARY ANGLE	SECOND ANGLE	CUTTER DIA.	PRIMARY ANGLE	SECOND ANGLE	CUTTER DIA.	PRIMARY ANGLE	SECOND ANGLE	CUTTER DIA.	PRIMARY ANGLE	SECOND ANGLE	CUTTER TOOTH ENDS
1/16"	22°	32°	5/16"	12°	21°	5/8"	10°	18°	1 3/8"	7°	13°	2 FLUTES PRIMARY ANGLE 7°
3/32"	18°	28°	11/32"	11°	19°	11/16"	9°	18°	1 1/2"	7°	13°	
1/8"	16°	28°	3/8"	11°	19°	3/4"	9°	17°	1 5/8"	7°	13°	3 FLUTES PRIMARY ANGLE 6°
5/32"	15°	26°	13/32"	11°	19°	13/16"	9°	17°	1 3/4"	6°	12°	
3/16"	14°	26°	7/16"	11°	19°	7/8"	9°	17°	1 7/8"	6°	12°	4 OR MORE FLUTES PRIMARY ANGLE 5°
7/32"	13°	24°	15/32"	10°	19°	15/16"	8°	16°	2"	6°	12°	
1/4"	12°	22°	1/2"	10°	18°	1"	8°	16°	2 1/4"	5°	11°	
9/32"	12°	21°	9/16"	10°	18°	1 1/8"	8°	14°	2 1/2"	5°	11°	

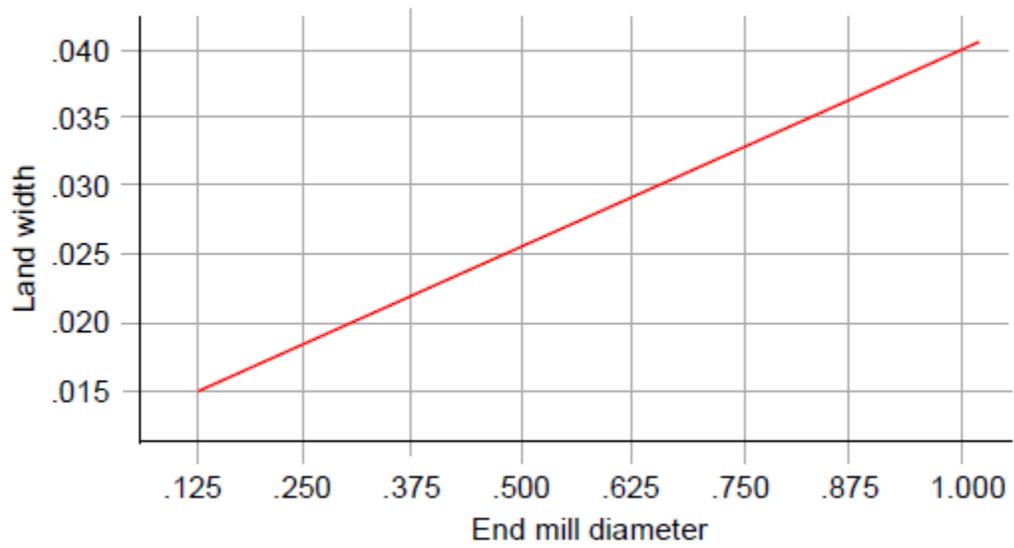
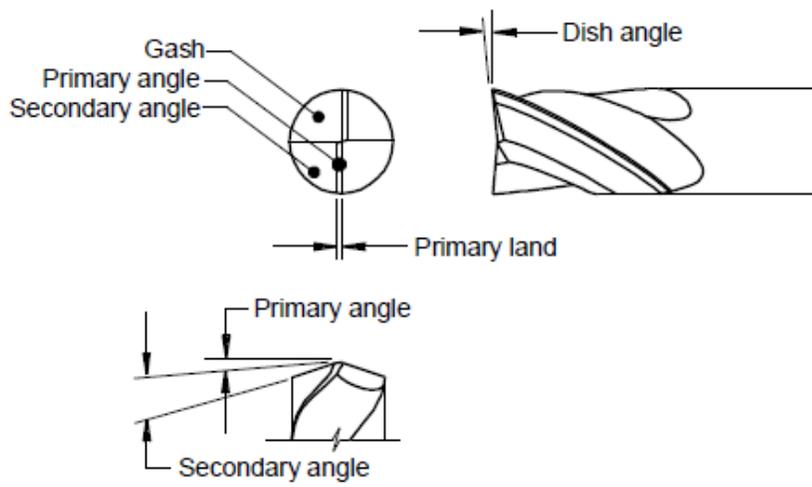
### Sharpening the end of the end mill

In addition to the above chart, there are suggested angles for the end of the end mill for various materials.

- Low carbon steel .....5 to 7 degrees
- High carbon and alloy steels ..... 3 to 5 degrees
- Cast iron .....4 to 7 degrees
- Brass and Aluminum ..... 10 to 12 degrees

The secondary angle on the end of the tool is generally 10 degrees greater than the primary angle. The primary land width should be between .015" and .030" depending on cutter size.

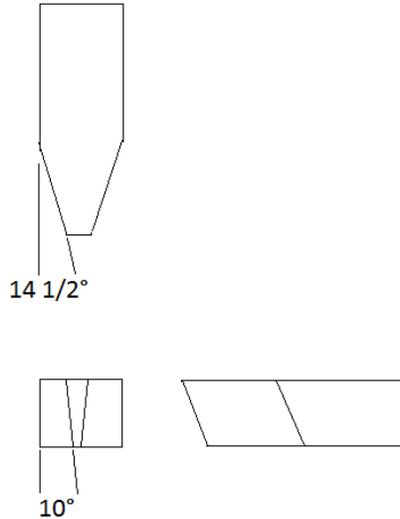
The "dish" angle on the end of all end mills should be 1 to 2 degrees.



## Tool Grinding

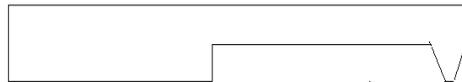
Many tools such as lathe cutting tools can be ground on the tool and cutter grinder. This can produce a better quality tool than hand grinding. I will include information such as angles and other information useful in making and using these tools.

### Grinding an ACME Threading Tool



The above images show the necessary angles used in grinding a tool to cut an acme thread. The thread requires an included angle of 29 degrees, or  $14\ 1/2$  degrees per side. The flat at the tip of the tool is a specific width for the TPI (threads per inch). There is a tool gage available for checking the tool. The sides need to be ground for clearance. This angle is not critical but should be around 10 degrees. A relief angle also is ground on the front of the tool to provide clearance below the tip of the tool.

Below is an image showing how an internal ACME threading tool can be ground from a square HSS lathe tool bit.



Some other useful Acme thread information:

- Thread depth =  $D$     Thread pitch =  $P$      $D = \frac{1}{2} P + .010$ "

$$\text{Minor diameter} = \text{Major diameter} - P + .020$$