



Surface Finish

Inserts

Surface finish may be an important specification on a machined part. Finishes produced by indexable insert cutters usually range from 32 to 150 Ra. This broad range can be affected by several variables such as work material, machine rigidity, spindle alignment, fixturing, insert nose geometry, insert wear, cutting feed and speed, heat-generated chip welding, and chatter.

Face Mills

Good finishes will result when you use the right combination of cutter geometry, insert style, and cutting speeds and feeds for the material being milled. It is also important to have the part adequately fixtured, and the machine properly maintained.

End Mills

Figure 1 illustrates that finer finishes can be obtained by using a larger corner radius, flat, or wiper on the insert. This tends to wipe out or reduce feed marks. In addition to the corner geometry of the insert, it is important to correctly set each insert relative to the other inserts. For example, if all of the inserts have the same corner geometry, and are set in the cutter body to a face height of approximately .001 relative to each other, the finish produced will be better than if the inserts were set to within .003.

Die and Mold

Improved finishes can also be obtained by increasing speeds and reducing feeds. Be aware, however, that increased speed also increases cutting temperatures, and may reduce insert edge life.

Slotting

Finish will not necessarily be the same on all areas of the milled surface. Figure 2 shows that the Ra finish will be lower on the area where the feed marks are close to each other, and higher where feed marks are farther apart.

Thread Milling

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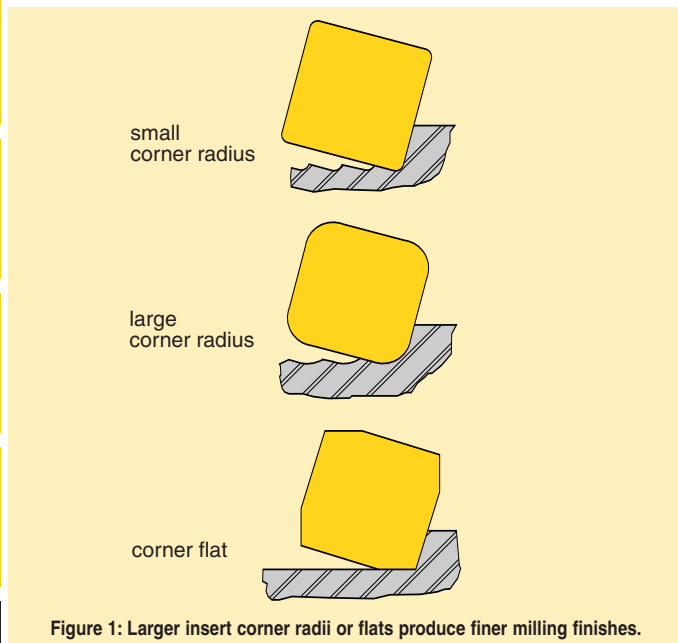


Figure 1: Larger insert corner radii or flats produce finer milling finishes.

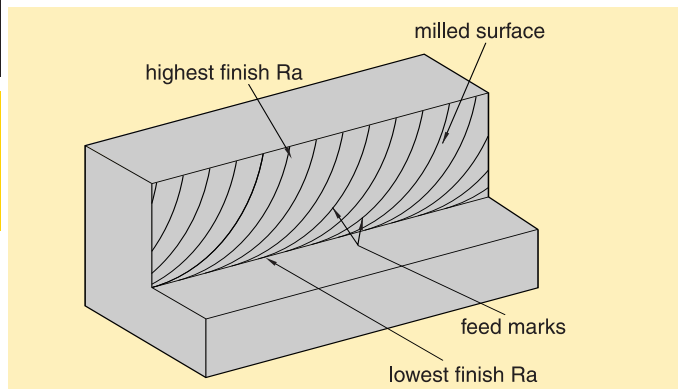


Figure 2: Quality of Ra finish corresponds to the distance between feed marks.

In figure 3, the Ra value will be lower near the outside diameter of the cut where the feed marks are at their closest, and higher at the center where the feed marks are farthest apart. Peaks produced are highest at the center of the cutter as it is positioned in the cut, and lowest at the outside diameter of the cutter, as illustrated below in figures 3 and 4.

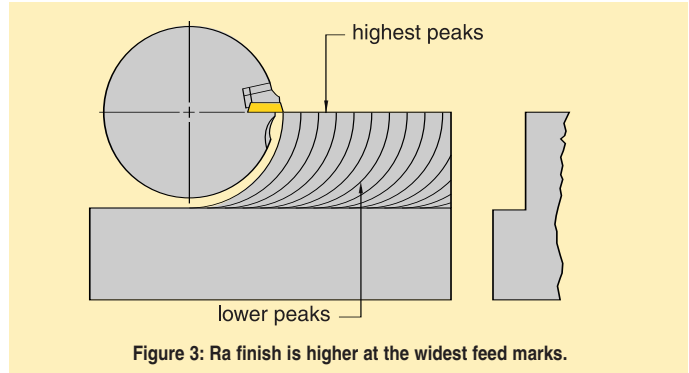


Figure 3: Ra finish is higher at the widest feed marks.

Both finish and flatness are affected by feed marks. A taper will be produced from the high peaks down to the low peaks.

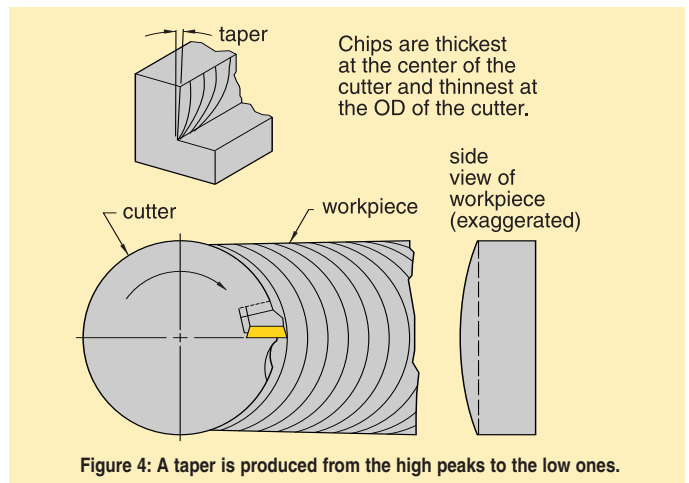


Figure 4: A taper is produced from the high peaks to the low ones.

Both finish and flatness are affected by feed marks. A taper will be produced from the high peaks down to the low peaks.

Flatness also affects part tolerance. This effect is more predominant in side milling both sides of a part as shown in figure 5.

An obvious solution to obtaining a more consistent and improved surface finish with a minimum of taper is to reduce or flatten the peaks between feed marks. This can be done by introducing an insert with a corner configuration capable of wiping out or reducing these peaks. Shown in figure 5 is an exaggerated change in part width due to flatness and taper.

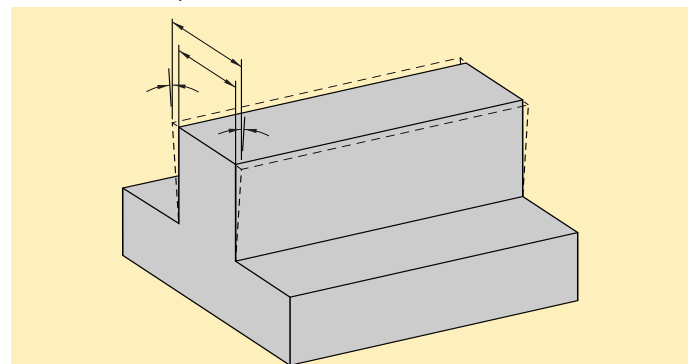


Figure 5: Flatness affects part tolerance more when milling both sides of a part.



Surface Finish (cont'd.)

Figures 6 and 7 compare the feed marks produced with a nose radius insert to those produced with a wiper insert. A wiper insert with a large radius for wiping out or reducing peaks, see figure 7, has been effective in producing finishes below 100 Ra. As you can see from reviewing figures 6 and 7, the wiper insert is designed to “top off” the peaks of the feed marks. An improved surface finish, surface flatness, and reduced taper will result.

Wiper inserts are normally set at .001 to .0015 above the highest positioned insert in the cutter to ensure a good wiping action. Kennametal wiper inserts are typically designed to fit into any pocket in the cutter body. This means one or more wiper inserts can be used. Being interchangeable, a wiper can be used to take its share of the load on the periphery of the cut in feed per tooth.

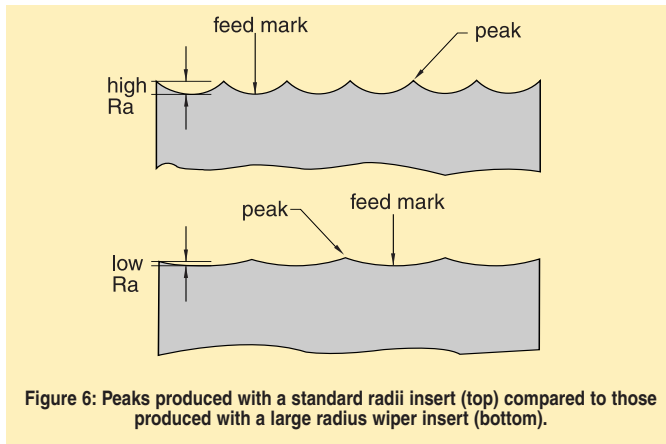


Figure 6: Peaks produced with a standard radii insert (top) compared to those produced with a large radius wiper insert (bottom).

Poor Surface Finish Being Produced

cause	solution
cutter runout	Check for high insert, dirt in the pockets, or dirty spindle and cutter mounting face. Also, look for burrs on the cutter and damaged cutter pocket.
worn or chipped insert	Index insert.
feed per revolution exceeding flat on wiper	Reduce feed rate or install wiper with greater effective insert facet width.
wiper insert is set too high	Set the wiper insert .001 to .0015 above highest insert.
chatter	Check rigidity of machine and table fixturing. Check arbor and spindle, adjust feed rates, adjust rpm, or reduce cut width. Consider cutter with fewer pockets.

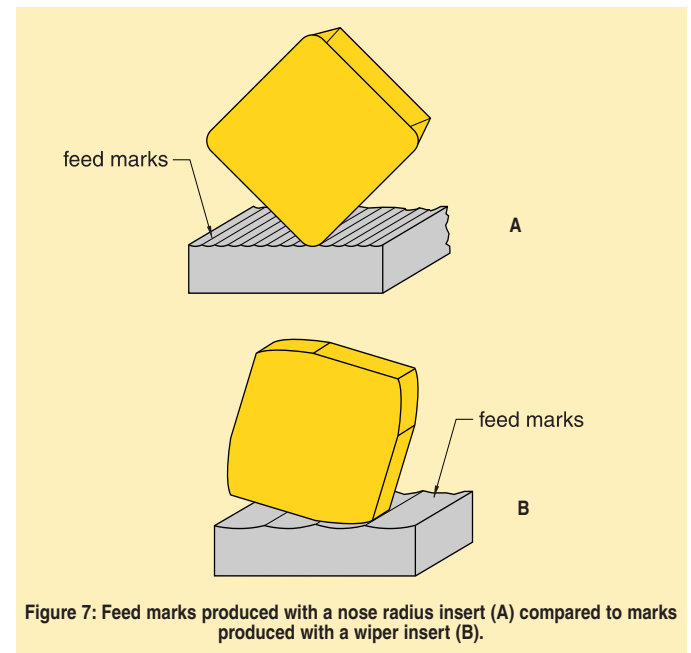


Figure 7: Feed marks produced with a nose radius insert (A) compared to marks produced with a wiper insert (B).

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measuring finish produced in a milling operation

Do not rely on your eye or fingernail to determine surface finish. Fingernails are about 25 times as thick as the stylus tip of a surface measuring instrument. They will skid across surface peaks, missing the valleys. Use a surface measuring instrument since the appearance of the surface finish may be deceiving. For example, reflected light on a uniformly milled surface pattern will look smoother than a random pattern. Also, a shiny surface will appear smoother than a dull surface.

Face Mills

End Mills

Placement of the measuring device in a specific area on the milled surface will affect the reading. Also, a surface finish measured perpendicular to the feed direction is better than measuring parallel to the feed direction. This is usually the case regardless of workpiece condition and material (see figure 8).

Die and Mold

Changing the cutoff width of the surface measuring instrument will affect the Ra value of the measurement.

Slotting

surface profile record

Figure 9 shows the variation in roughness created by increasing the cutoff width on the instrument. The greater the cutoff, (see figure 9), the higher the Ra finish. For example, figure 10 illustrates that a .010 cutoff width will produce a 25 Ra finish; whereas, a .100 cutoff width will produce a 75 Ra finish.

Thread Milling

Also, figure 10 demonstrates that most measuring devices are provided with .010, .030 and .100 cutoffs. In most cases, the .030 width cutoff is preferred.

Figure 11 shows the standard surface symbols specifying maximum and minimum roughness, waviness, and lay... which is the direction in which the measurement is taken.

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Preferred Method

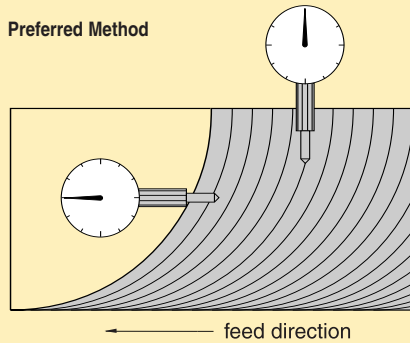


Figure 8: Measuring surface finish

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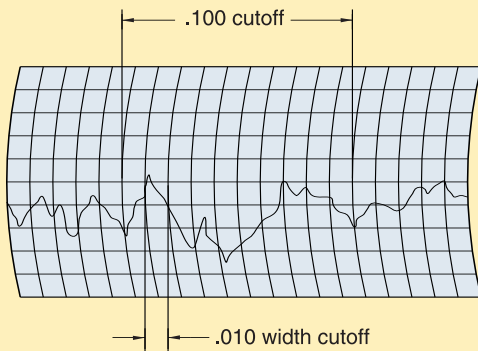


Figure 9: Increasing the cutoff width creates a variation in roughness.

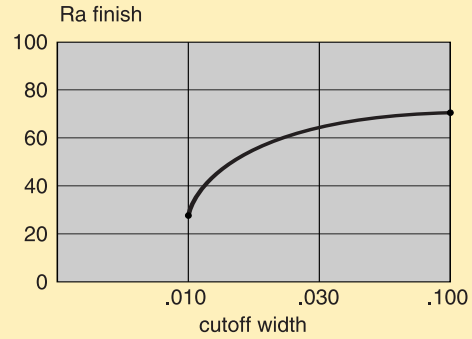


Figure 10: Finish quality is directly proportional to the cutoff width.

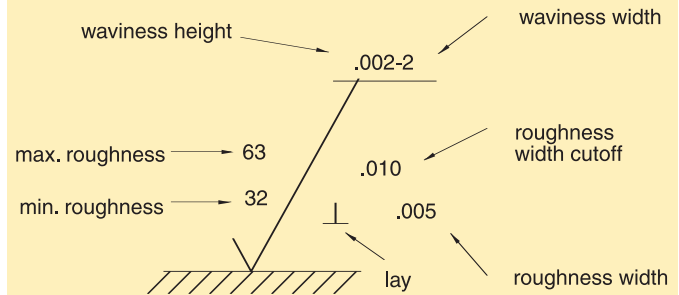


Figure 11: Standard surface symbols