Surfacing with a Square Endmill Dakota Bass

Surfacing, or 3D milling, is almost exclusively limited to ball end mills. However in some cases it's much faster to surface with a large diameter face mill or indexable tool. This may sound a little crazy, but the results are dramatically faster cycle times and eliminated secondary operations. There are 2 distinct situations where clever programming can allow one to replace the ball end mill with a square end mill: when milling external 2D splines and when replacing a simple secondary operation. Two example parts were made to show how to implement this.

Fundamentally how does surfacing with a face mill (or any large tool) work? It comes down to the fact that if you have a small stepover and a large diameter, the arc length is approximately flat near the edge. This is just like how the Earth appears flat to us on the surface, the curvature is too miniscule to notice. There are three factors that affect the scallop height or flatness: tool diameter, milling angle, and stepover.

For example, a machined sloped surface made with a 3 inch face mill, a 10 degree angle, and a 0.1 inch stepover will be flat to 1.5 tenths (.000147"). As a general rule of thumb, large tools with small stepovers will be flat to less than half a thousandth of an inch. If you need an exact value, the following equation predicts the scallop height (units: angle is in degrees, diameter and stepover are in inches).

$$Flatness = 0.000022*Angle + 0.00044/Diameter + .015(Stepover)^{2.01} - 0.00037$$

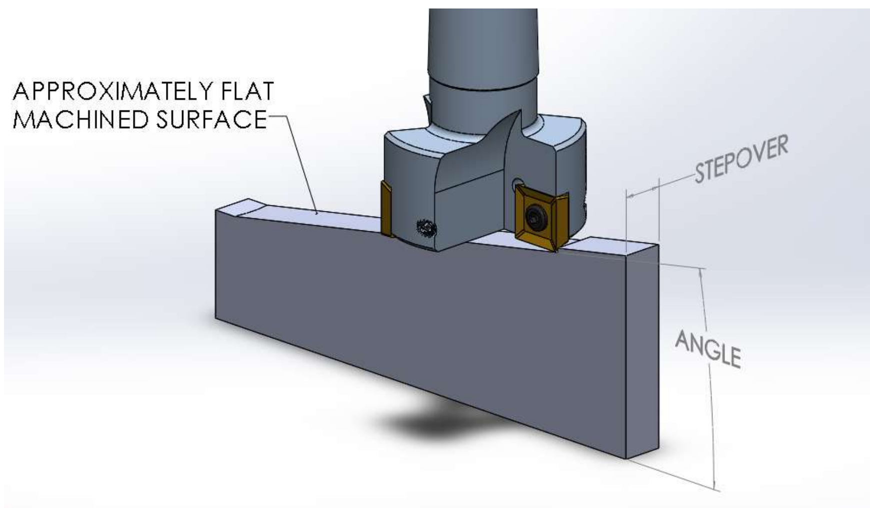

Figure 1. Machining a slanted surface simulation

Eliminating Secondary Operations

There are several situations where this technique can used to replace what would previously have to be machined in a secondary operation. This example part (a business card holder made in the advanced machining lab at California Polytechnic University San Luis Obispo) would typically be made in 3 ops: machine the bottom features, machine the top features, and then machine the slanted surface on the side.

By using a 1 inch diameter indexable end mill to surface mill the slanted surface, the 3rd operation was eliminated. Programming this isn't something CAM software houses have taken advantage of yet, but it's simple to implement. The slant is simply rough machined using standard techniques, so that the depth of cut on the finishing pass with the 1" end mill is low enough to achieve a cosmetic finish.

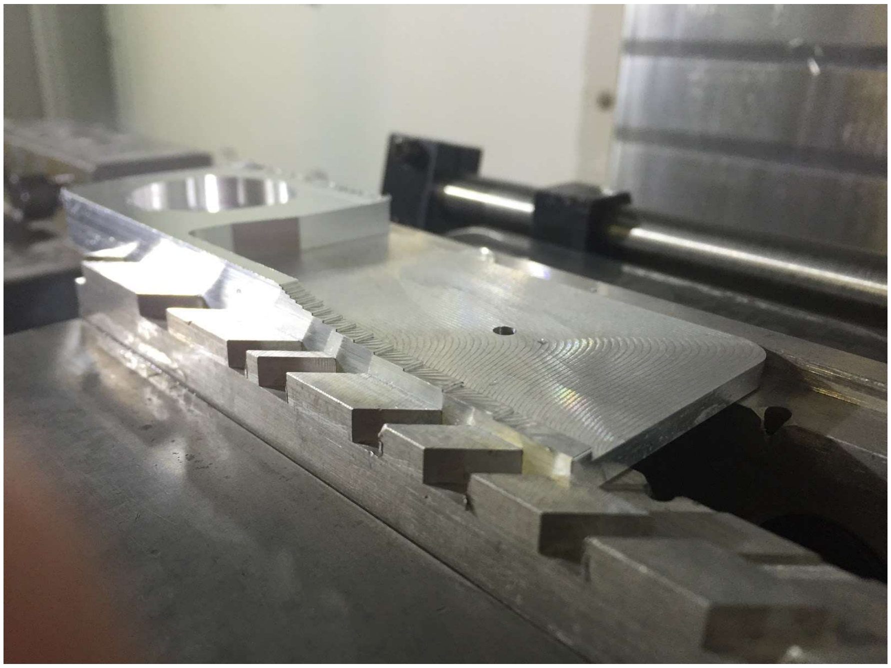

Figure 2. Example part after rough machining the slanted surface.

For programming the finishing pass, the curved spline was offset by the tool radius, and this spline was used as the toolpath using a standard "Trace" operation. The end result was a lower overall cycle time and 50% fewer set ups.

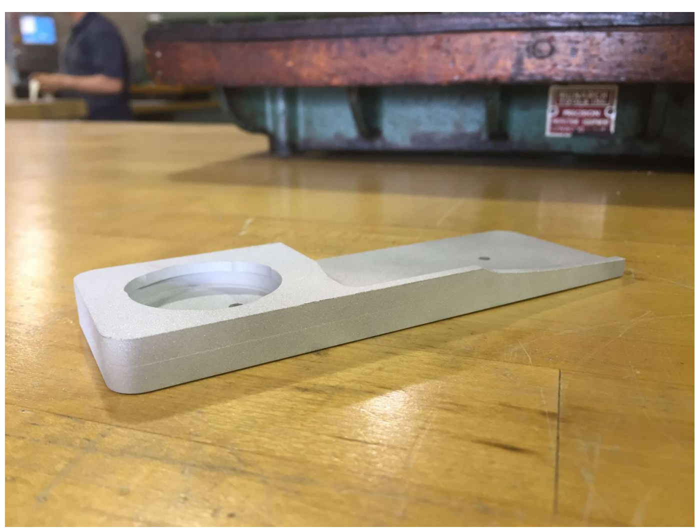

Figure 3. Finished example part

Milling external 2D spines

There are some types of surfaces that are typically machined with ball end mills but are suitable for this type of surfacing: external rounds or splines that have a constant cross section. To illustrate this fact, a pair of AL7075 wayfarer style sunglasses were machined on a VMC.

Normally a ball end mill would surface mill the nose rest, which would be a time consuming process for a consumer part. However by replacing the ball end mill with a 3 inch diameter face mill, the nose rest was machined in a single pass. Ultimately cycle time was reduced by several minutes and surface quality was improved.

Figure 4. Wayfarer sunglasses, example part.