

## **Technical Tip #115 – HSS End Mill Accuracy and Deflection**

Because end mills are supported only at the shank end, they are subject to deflection, which can reduce the accuracy of the milled part. Several factors affect the amount of deflection that will occur:

1. **Overall Length and Length of Cut:** As the length of the mill increases, difficulty in maintaining dimensional accuracy also increases. Rigidity decreases in proportion to length of cut to the 3<sup>rd</sup> power. Thus, a 4" length of cut is 1/8 as rigid as a 2" length of cut. A regular length end mill cutting 7075 aluminum can deflect <.002", while an extra-long end mill can deflect >.006".
2. **End Mill Diameter:** Rigidity increases in proportion to diameter to the 4<sup>th</sup> power. A 1"-diameter end mill is 16 times more rigid than a 1/2" end mill. A 1"-diameter end mill over a 5/8" length of cut in 1040 steel will cut to size, while a 3/8"-diameter end mill may deflect to >.003".
3. **End Mill Material Composition:** Solid carbide is about three times more rigid and resistant to deflection than high-speed steel end mills, but not as tough.
4. **Radial Depth of Cut and Axial Length of Cut:** Heavy radial cuts as well as long axial lengths of cuts will deflect the end mill much more. A light-finishing pass is generally required to produce accurate parallel cuts.

### **Tips:**

- ***Always use the shortest tool possible.***
- Shorter tools can reduce chatter.
- Increase coolant.
- Try left-hand spiral end mills.
- Try using higher helix end mills.
- Increase overall system rigidity.
- Reduce overhang.
- Conventional milling can resist deflection better than climb milling.
- Dull tools deflect more than sharp tools.