Milling Stainless Steel

A quick and dirty cheat sheet

Machining stainless is tricky; it requires a level of care and attention to detail that aluminum and plastic do not. It takes a lot more energy to machine stainless, so if you try to do it improperly you will destroy your tools and your part - and quite possibly injure yourself.

The Alloy

There are many alloys of Stainless, all are difficult to machine, although some are easier than others. In most cases, type 303 is the best choice since it is easier to machine than most other alloys. Its only drawbacks are expense ($6/lb, 1997 prices) and the fact it can be hard to find. Ignore the myth that it is not weldable; it is only slightly more difficult to weld than other stainless alloys.

The McMaster-Carr catalogue has an excellent short description of stainless alloys; Machinery's Handbook is a more extensive reference.

The Machine

By far the best machines to use are the Haas Machining Centers since they have both a very stiff spindle and flood coolant. The stiff spindle reduces chatter, and the flood coolant is essential for keeping the tool cool.

CNC vs. Manual

For any reasonable size job you will want to use CNC control. This allows you to maintain a constant feed and gives you two free hands to monitor the very important coolant situation.

Fixturing

Because cutting stainless requires so much machining horsepower, your setup needs to be extremely stiff. Flimsy setups are quite dangerous (they can lead to workpieces moving at high velocities in your direction). They also cause chatter, which will destroy your tool and give your part a lousy finish. Double stick tape is out of the question for stainless.

Coolant

Without coolant, you will destroy even a sharp tool in seconds. The tool will heat up (often becoming red hot) then quickly become dull. Flood coolant is much better than any intermittent coolant you will be able to apply. Currently the Haas machines are the only machines in PRL with flood coolant capability. They use a synthetic water-based coolant.

When using flood coolant on the Haas, be sure that the coolant is always getting to the tool. Sometimes the geometry of your part will be such that some of the workpiece blocks the coolant from getting to the tool. A nice trick is to hook up the garden hose to the coolant and manually aim it at the tool.

Be careful to not splash coolant on yourself, others, or the floor. It may cause an allergic reaction, a rash, and be quite a mess. Remember, you will have to clean up after you're done!

Cutting Tools

Generally, it is best to use carbide tools. Carbide steel is harder and stiffer than high speed steel. This means you can run the machine at higher spindle speeds, which, in turn, allows running at faster feeds and therefore reduced cutting time. Carbide tools are very brittle and do not like extreme changes in temperature. You must either not use coolant when using carbide tools (not recommended for machining stainless), or use flood coolant. If you apply coolant intermittently, the temperature fluctuation will fracture a carbide tool. A general guideline is to pick a spindle speed of 2 to 3 times what you would use for a high speed steel tool.

Roughing endmills are also nice (although not as good as carbide) since they dissipate heat better than high speed steel cutters. Cutters that get too hot quickly become dull and useless.

Choose a cutter with a lot of flutes. The more flutes on a cutter, the less chip load per flute. This is different from aluminum machining, where it is sometimes better to have fewer flutes to avoid clogging of the material between the flutes. (Clogging due to a lot of flutes isn't usually a problem with stainless since the depth of cut is much smaller.)

Climb vs. conventional cut.

Climb cut gives a better finish than a conventional cut if your machine is a decent (stiff) machine. The Haas machines are definitely decent.

Determining your speed, feed, and depth of cut

Here are some numbers empirically determined for running stainless steel in a CNC machining center with flood coolant.

Spindle Speed

Calculate using the formula: $$SpindleSpeed = \frac{(CuttingSpeed) * 4}{ToolDiameter}$$

Cutting Speed for stainless steel, high speed steel cutter on a manual milling machine = 50
Cutting Speed for stainless steel, carbide cutter on a manual milling machine = 125
Cutting Speed for stainless steel, high speed steel cutter, flood coolant on Haas = 100
Cutting Speed for stainless steel, carbide cutter, flood coolant on Haas = 250

Feed

Program in the feedrate you get from the following formula or choose something slightly higher. When you machine, turn the feedrate knob way down. Then turn it up to where it sounds good. An experienced TA can help you figure out when it "sounds good."

$$Feed = (ChipLoad) * (n) * (Speed)$$

ChipLoad for stainless steel =.002 inch/tooth

Depth of cut:

Generally determined by the horsepower of the machine. For stainless, a good rule of thumb is 1/8th of the cutter diameter. Too shallow a cut actually work hardens the material, which will destroy your cutter.

revision history

rev 0	9/97	Chuck McCall	original text
rev 0.1	8/01	Katherine Kuchenbecker	minor revisions