MACHINING NIOBIUM

All the normal machining techniques can be used for niobium. The metal has a strong tendency to gall, however, and special attention must be paid to tool design and lubricant use. In lathe turning, the metal behaves very much like soft copper. The use of high-speed tooling with adequate lubrication and cooling with soluble oil (or other suitable product) following the parameters given here is recommended.

Although carbide tools can be used, the tendency to gall is more pronounced with them than with high-speed steel. In turning, the metal should be removed in a shearing action and the chip allowed to slide off the tool surface. When build-up of the chip occurs, the resulting pressure breaks the cutting edge of the tool.

The machining recommendations shown in the accompanying table generally give satisfactory results. The minimum surface speed of 80 feet per minute is important. Slower speeds will cause the metal to tear, particularly annealed stock. Normally, unannealed metal is preferred for lathe operations.

**Tooling Recommendations for Machining Niobium:**

Approach angles: 15° - 20°

Side Rake: 30° - 35°

Side and End Clearances: 5°

Plan Relief Angle: 15° - 20°

Nose Radius: .020" - .030"

Cutting Speed: 60 - 80 feet / minute with high speed steel; 250 - 300 feet / minute with carbide tools.

Feed, Roughing: .008" - .012" / revolution

Feed, Finishing: .005" maximum / revolution

Depth of cut: .030" - .125"

**Drilling:**

Standard high-speed drills can be used with good results. The peripheral lands of the drill should be checked often for excessive wear to prevent drilling undersized holes.

**Thread Cutting:**

Standard techniques for thread cutting can be used when enough lubricant is available to reduce the galling tendency and consequent tearing of the metal from the surfaces. In threading larger diameters, it is better to cut the threads on a lathe rather than with a threading die. When dies or taps are used, they must be kept free of chips and cleaned frequently.

**Grinding:**

Grinding niobium is difficult, at best. Most grinding wheels have a tendency to “load”, and silicon carbide wheels such as Carborundum 120-T (for rough grinding) and 120-R or 150-R (for finishing) should be used. An adequate supply of cooling water is desirable.
Blanking and Punching:

Dies and punches made of steels usually used for this purpose are satisfactory for niobium. A 6% clearance between the punch and the die is recommended. Light oils or similar lubricants should be used to prevent scoring the dies.

Form Stamping:

Beryllium copper, aluminum bronzes, and steel may be used for tools. The techniques used can be the same as used for stamping of steel. The tools should be polished to reduce the tendency to gall as much as possible. Light oils or similar lubricants should also be used, again to reduce the chances of galling.

Deep Drawing:

Annealed niobium can be deep drawn without too much difficulty. Tool materials recommended for form stamping are also good for drawing operations. Single draws where the depth of the draw does not exceed the diameter of the blank can be accomplished. If more than one draw is to be made, the first draw should not have depth greater than 40% of the blank diameter. Intermediate annealing in a vacuum may be desirable with multiple draws. Sulfonated tallow and Johnson’s 150 Drawing Wax can be used as lubricants.

Spinning:

Niobium can be spun by conventional techniques using wood formers and steel roller wheels in conjunction with an adequate lubricant such as sulfonated tallow or Johnson’s 150 Wax. Spinning is done at room temperature. Beryllium copper or aluminum bronzes are adequate for the tooling. The metal should be worked in small steps or stages with long sweeping strokes using light pressure rather than a few heavy strokes.

Welding:

As already stated, niobium is a very reactive metal. It reacts with all of the common gases: hydrogen, nitrogen, oxygen, carbon monoxide, and carbon dioxide. The metal also reacts with surface contaminants such as oil, grease, residues from degreasing solutions, and residues from cleaning fluids such as acetone. It is for these reasons the surfaces of metal to be welded, either by fusion or resistance welding must be absolutely clean before welding.

An acid etch in a solution of 45 parts nitric acid, 1 part hydrofluoric acid, and the rest water at ambient temperatures or up to 65 °C (150 °F) is acceptable. The amount of hydrofluoric acid may be increased if a more severe etching action is needed. The metal should be thoroughly rinsed after etching, preferably in distilled or deionized water.

Resistance Welding:

Resistance welding of niobium to niobium and certain other metals can be done with conventional equipment and techniques. Because of its high melting point and relatively low electrical resistance, niobium requires a high power input to obtain a sound weld. Weld duration should be kept as short as possible, preferably 1-10 seconds (60 Hz) to prevent excessive heating of the weld area. If at all possible, the work should be flooded with water. In seam resistance welding, the work actually should be submerged in water, to exclude both air from the heat-affected zone and to cool the metal as rapidly as possible.

RWMA Class 2 welding electrodes are recommended and should have water cooling. Any copper pick-up on the niobium could be easily removed by pickling in nitric acid, which will not attack niobium. As already emphasized, the parts to be welded must be thoroughly cleaned before welding. After the parts have been cleaned, they should be handled with lint-free cotton gloves so that body oils will not contaminate the surfaces.
Fusion Welding:

Strong, ductile fusion welds can be made with niobium using TIG welding. Because of the weld’s reactivity with air, certain modifications to the TIG method must be made.

The best approach is to weld in a chamber, using argon or a mixture of argon and helium. If chamber welding is not practical or not available, welding in a normal atmosphere can be done with proper fixturing to provide an inert gas atmosphere not only for the molten zone, but also for the heat affected zone. Trailing shields are necessary to protect the fusion zone during cooling and the metal must not be exposed to air until the temperature has dropped to 260 °C (500 °F) or lower. The back side of the weld zone must also be protected with inert gas shield during both the welding and cooling cycles.

Normal sheet with a thickness of .050” (1.27 mm) or less can be welded without using a filler rod. Heavier sheet often requires the use of filler rod. Bare rod should be used. Use of coated rod or any flux is not good practice, since molten niobium reacts with all of the known fluxes. Cleanliness of the material to be welded as well as the filler rod is essential.