

MACHINING ZIRCONIUM

Typical Mechanical Properties:

Modulus of Elasticity (psi): 14.4×10^6

Shear Modulus (psi): 5.25×10^6

Poisson's Ratio (Ambient Temp.): 0.35

Speed of Sound Through Zr: Long: 1.8×10^5 in/sec

Shear Wave: $.886 \times 10^5$ in/sec

Zirconium can be machined by conventional methods. Three basic parameters should be used for all machining operations:

- Slow Speeds
- Heavy Feeds
- A flood coolant system using a water soluble oil lubricant.

Zirconium exhibits a marked tendency to gall and workharden. This indicates that higher than normal clearance angles on tools are needed to penetrate the previously workhardened surface and cut a clean coarse chip. Satisfactory results can be obtained with both cemented carbide and high speed tools, however, the carbide usually gives better finishes and higher productivity. Polishing or honing the cutting edges will give the tool added life. Zirconium machines to an excellent finish, requiring relatively light horsepower compared to alloy steel. The tool forces are relatively low. Fine chips should not be allowed to accumulate on or near the machining equipment as they can easily be ignited. Zirconium can be turned readily without difficulty if sharp tools and a coolant lubricant are used.

Milling:

Both vertical face and horizontal slab milling give good results. Wherever possible, zirconium should be climb milled to penetrate the work at the maximum approach angle and depth of cut while emerging through the workhardened area. The faces and edges of milling cutters should be kept very sharp. A set of herringbone cutters will permit positive axial rake angles to be effective at both sides of a recess. Optimum surface finish and tool life are obtained when the tool is ground with a positive 12° to 15° radial rake along with cutting corner. A high spiral flute should also be used. The work should be flooded or sprayed with a coolant to completely wash away all chips from the tool. The penetration can range from 0.005 to 0.010 inch per tooth at 150 to 250 SFPM. The work absorbs about 10 percent of the cutting energy with sharp cutters. Zirconium requires only about 75 percent of the horsepower required for SAE 1020 CR steel.

Grinding:

Zirconium can be specified for applications where extremely close dimensional tolerances and high quality surface finishes are required. The grinding methods used for zirconium involve standard machine equipment for all functions such as surface grinding, cylindrical grinding, centerless grinding and belt grinding. In addition, all standard abrasive equipment such as abrasive wheels, coated abrasives, and lubricants can be used. The use of straight grinding oil or oil coolant produces a better finish and higher yields as well as preventing ignition which can occur from fire, dry grinding swarf.

Wheel Grinding:

Zirconium produces a white stream of sparks. Conventional speeds and feeds are satisfactory and silicon carbide generally gives better results than aluminum oxide. At light infeeds and slow wheel speeds, higher grinding ratios are produced. At heavier infeeds and slow wheel speeds, lower grinding ratios are produced. The finishes produced are in relation to the grinding ratios. Higher grinding ratios, which mean less wheel breakdown, produce finer finishes. The effect of the grinding fluid on zirconium is the same as for other metals. Straight grinding oils produce higher grinding ratios than water miscible fluids at all infeeds.

A cylinder is generally much easier to grind than a flat surface. Cylindrical grinding of zirconium can be done with aluminum oxide wheels. The same applies to snagging. In cut-off work, silicon carbon rubber wheels prove to be most successful.

Belt Grinding:

Belt speed and contact wheel selection are two primary considerations when grinding zirconium. Recommended belt speeds are 2,000 to 3,000 SFPM at low grinding pressures with 50 grit and coarser material, and 2,500 to 3,500 SFPM with 60 grit and finer belts with similar working pressure. At high grinding pressures, 2,500 to 3,500 SFPM are recommended with 50 grit and coarser and 3,000 to 4,000 SFPM with 60 grit and finer.

Contact wheels should be relatively hard and aggressive. Soluble oil coolants alone, or mixed with water and applied in a flood are recommended. Resin abrasive cloth may be used with oil and rubber contact wheels on general polishing operations. Resin Industrial Cloth Type 3 or Type 6 are recommended for use with oil in grinding operations where high grinding pressures are used. Similarly, waterproof cloth silicon carbide for light work and aluminum oxide for heavy work may be effectively employed with soluble oil and water coolants.