The Right Tool for Machining Beryllium

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Cemented tungsten carbide tools are manufactured by a powder metallurgy process. Tungsten carbide powders along with lesser amounts of other carbides are blended with cobalt powders and cold pressed to consolidate the mixture. The added carbides are those of tantalum and titanium. The consolidated mixture is then sintered at a temperature high enough to melt or partially melt the cobalt binder.

Beryllium is machined using tungsten carbide machine tools that are designated as C-4 by the industry. The C-4 grade of machine tool, shown in Table 1, can be used for non-ferrous materials such as beryllium. The grading system, as determined by the industry, is general in nature and not specific enough to match a specific metal and carbide. Recently an equivalent grade of machine tool was purchased which was found to be unsatisfactory when used on beryllium. A study was undertaken to determine what specific tungsten carbide machine tools within the C-4 designation could be used for beryllium. Machine tools from other designations were also evaluated.

Machine tools from the C-2, C-4, and C-7 designation were examined in this study. Overall twelve different machine tools from these grades were evaluated. Each machine tool was used to machine beryllium and then examined to determine wear characteristics. They were then polished and etched to reveal microstructure. The microstructure was examined on a scanning electron microscope (SEM) equipped with an energy dispersive spectrometer (EDS).

The machine tools were used to make a 0.005 inch cut on a beryllium blank and then examined in the SEM. Figures 1 and 2 show a comparison between a "good" and a "poor" machine tool. The "good" machine tool performed well with a very small amount of flank wear. "Poor" machine tools had large amounts of flank wear and some cratering. There was also some buildup of material along the edge of the tool and in the crater.

Metallographic examination of the machine tools, shown in Figures 3 and 4, revealed a dramatic difference in their composition. Shown in the figures are both secondary and backscatter electron images of the etched machine tools. The "good" machine tool, Figure 2, has tungsten carbide particles that are very sharp and have a particle size from 0.5 to 2.0 microns. Backscatter image and EDS have shown this machine tool to be tungsten carbide particles with a cobalt binder. The "poor" machine tool, Figure 3, has a large number of rounded particles that range in size from 1.0 to 2.5 microns. Composition of this machine tool is tungsten carbide, cobalt, tantalum and titanium. Results of this study have shown that, in general, machine tools in the C-4 classification that are tungsten carbide and a cobalt binder will work satisfactorily for machining beryllium. All of the machine tools that had tantalum and titanium additions proved to be unsatisfactory.

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Table 1. Carbide Machine Tools for Metal Cutting Applications

Industry Grade	Material	Working Methods
C-1	cast iron non-ferrous	Roughing cuts
C-2	cast iron non-ferrous	General purpose machining
C-3	cast iron non-ferrous	Light finishing cuts
C-4	cast iron non-ferrous	Precision boring
C-5	steel	Roughing cuts
C-6	steel	General purpose machining
C-7	steel	Finishing cuts
C-8	steel	Precision boring

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Metallographic Technique

Grinding of the tungsten carbide machine tools was done on diamond impregnated wheels. Rough polishing was done with 15, 6 and 1 micron diamond on nylon cloth. A fine polish with 0.06 micron colloidal silica on a medium napped cloth produced a very good surface for etching. Etching for five minutes with Murakami's reagent (10 grams potassium ferricyanide, 10 grams sodium hydroxide and 100 mL water) revealed the machine tool microstructure.

Figure 1. Secondary electron image of a "good" machine tool with a very small amount of flank wear. 60X

Figure 2. Secondary electron image of a "poor" performing machine tool showing a large amount of cratering and flank wear. 60X

(a) Secondary

(b) Backscatter

Figure 3. A secondary and backscatter electron image of a "good" machine tool microstructure with tungsten carbide and cobalt binder. The tungsten carbides are the angular white particles and the binder appears as the dark material in the backscatter image.

(a) Secondary

(b) Backscatter

Figure 4. A secondary and backscatter electron image of a "poor" machine tool microstructure that has tungsten carbide, cobalt binder and additions of tantalum and titanium. Light areas of the backscatter image are tungsten carbide and dark areas are cobalt binder. Light to medium gray areas are tantalum and titanium.