



Metalworking

'Ugly Stuff': Machining Tungsten Is Never Easy—But You Can Make It Easier

Kip Hanson | Jan 24, 2023

Some metals have earned a reputation on shop floors for wearing out, breaking or otherwise destroying cutting tools in short order. Tungsten is one.

Machinists who work with it are often caught in a nonstop cycle of adjusting offsets and replacing tools, while straining to avoid failures that would scrap an expensive workpiece.

William Durow, manager of the Global Engineering Project Office for Sandvik Coromant US in Mebane, North Carolina, has machined most metals, and he's not ashamed to admit that tungsten tests his mettle. "It's ugly stuff," he says.

Sandvik Coromant, which has extensive machining and test facilities, employs experienced personnel such as Durow to work with customers on their machining challenges and develop cost-effective solutions.

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As with other durable metals and alloys, some of the same qualities that make tungsten difficult to machine render it valuable to a variety of manufacturers.

Durow has seen the metal used in everything from golf club heads (where it increases mass) to radiation shielding (due to its extreme density, nearly twice that of lead).

"We see it quite a bit in medical and defense components, but the main consumer is rocket manufacturing, where manufacturers use it to make nozzles," he says. "Lots and lots of nozzles."

Denser Than Gold and Creep-Resistant

What exactly is tungsten, and what makes it so challenging? It is a refractory metal, belonging to a group of elements known for their extreme resistance to heat and wear. Sitting at Number 74 on the periodic table, tungsten is identified with a W because of its original name, wolfram.

Like its cousins niobium, molybdenum, tantalum and rhenium—a few of which occasionally make their

way onto the machining floor—tungsten is chemically inert. It's also highly stable, has the lowest expansion coefficient of all metals, and is very resistant to creep, defined as the tendency to deform plastically under stress and elevated temperatures.

While tungsten is denser than even gold, it's also extremely hard. Its melting point of 6192 degrees Fahrenheit (3422 degrees Celsius) is high, like all refractory metals, second only to carbon—which vaporizes at such temperatures rather than melting.

Because of that, tungsten cannot be cast, forged or rolled like other metals but must be pressed into shape while in powder form and then sintered. It is frequently alloyed with other metals, such as super duplex steels and tool and high-speed steels.

So-called heavy alloys, notably, are mostly tungsten mixed with a small amount of nickel, copper, titanium or iron. This group, covered under industrial standards ASTM-B-777, AMS-T-21014 and AMS-7725, comprises most of the tungsten-based materials that challenge Durow and countless other machinists.

Fighting Tungsten with Tungsten

One of this element's most common uses is in cemented carbide. The indexable inserts and solid carbide drills and end mills used in many machine shops each day are composed of equal parts tungsten and carbon, held together with a small amount of cobalt binder. So are surgical tools, fishing weights, industrial gears, and even wedding bands.

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It's ironic, then, that this is the cutting tool material that Durow most often recommends. "Polycrystalline diamond, cubic boron nitride, ceramics—I've tried them all," he says. "Yes, they work to a certain extent, but when it comes to the balance of cost vs. tool life, I think carbide is probably the most effective solution."

He also recommends using a tool with precision-ground cutting edges, since the sharpness helps to reduce the friction that leads to insert-killing heat.

Choose a thin, wear-resistant Chemical Vapor Deposition (CVD) coating if available, he suggests; otherwise go with a PVD (Physical Vapor Deposition) coating. Both help to protect the insert against tungsten's abrasiveness.

"I've had my best luck with S205, a carbide grade that Sandvik Coromant often recommends for the finish machining of nickel-based superalloys like those found in aerospace applications," Durow says.

Whatever type of cutting tool material you choose, take the work slowly and steadily, he adds. While some online machining resources suggest parameters similar to those for cast iron, Durow takes a more conservative approach.

Depending on the part geometry and grade of tungsten, he starts with cutting speeds of 100 to 150 feet per minute. To avoid tool chipping, he applies relatively light feed rates and depths of cut—half of what's recommended for Inconel is probably a good starting point.

Regardless, machinists should expect the job to require plenty of inserts. "This material is extremely abrasive. It's nasty and hard, so cutting tools will wear out quickly no matter what, but if you develop a predictable process and resign yourself to frequent tool changes, it's manageable."

Finding the Right Setup

Part of this predictable process relies on a rigid machine tool and setup. Any instability, chatter or vibration will probably result in a chipped tool.

A light-duty commodity machine might work, but at the cost of further reducing the already wimpy feed rates and depths of cut suggested earlier. And since tungsten cutting speeds are much lower than most materials, the machine should have sufficient torque at low rpm, lest stalling occur.

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If your machine tool is equipped for it, use high-pressure cutting fluid mixed to a concentration level of at least 12 percent, with 20 percent not out of the question.

Somewhat surprisingly, some customers have been successful using straight oil, Durow says. The cutting speeds are low enough that there's little risk of fire, and oil's higher lubricity helps combat the extreme pressures encountered when machining tungsten.

"Whatever it takes to get the heat out of there and reduce friction," he says.

Tungsten isn't the worst material Durow has ever machined—that honor goes to "some crazy beta titanium," he says, but it ranks a close second.

"We've seen anywhere between four minutes to 40 minutes of tool life," he adds, laughing. "This stuff is just not friendly to carbide. But sometimes that's the nature of the beast with machining, and done properly, you can be quite successful with tungsten. All it takes is the right setup, a healthy supply of high-quality carbide and plenty of patience."

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