Metalworking

Machining Tips to Help You Conquer the Cobalt Blues

Kip Hanson | Oct 17, 2023

The metallic element cobalt sits at number 27 on the periodic table, right between iron and nickel and a few boxes down from chromium at number 24, but unless you stumble across a cobalt-rich meteorite, you probably won't find it in its pure form.

Practically all cobalt is tied up with elements like arsenic and sulfur in various ores, most of which come from the Congo and Indonesia. Varieties include cobaltite, erythrite and skutterudite, the latter of which contains plentiful amounts of nickel, cobalt's periodic table neighbor.

Chromium, though more accessible, is also hidden in the ground, most often in the form of chromite ore. Like nickel, it is an essential partner in various alloys, although its most common use is to make otherwise rust-prone steels resistant to corrosion or, in other words, stainless.

Chipping and BUE

From a metalworking standpoint, alloys high in cobalt, chrome, nickel and more often, each of these, share many unfortunate similarities.

Fast tool wear is a common failure mode. With that comes poor surface finish and a nonstop struggle to maintain dimensional accuracy. ***Built-up-edge (BUE)*** is another, which causes chipping when chunks of welded-on workpiece material break away. Similarly, depth-of-cut notching is a regular occurrence but is often mistaken for built-up edge.

These metals are also prone to work hardening, making proper toolpath selection critical. And most cobalt and cobalt-chrome (CoCr) alloys boast a unique combination of hardness and toughness that makes chatter and tool deflection almost routine.

Alloys Used in Jet Engines, Race Cars and Orthodontics

Perhaps the best-known cobalt-chromium alloy is Stellite—the stuff of hardfacing material, extrusion dies and nuclear reactor components—which contains 57 percent cobalt.

It was invented more than 100 years ago by American metallurgist Elwood Haynes, sold to Firth-

Sterling two decades later and acquired by Kennametal in 1940.

Chances are good that some MP35N will appear in your family photos, if you or someone you know wears braces. A high-performance, corrosion-resistant alloy, MP35N is made of equal parts nickel and cobalt (35 percent each), with chromium and molybdenum thrown in for good measure.

This makes MP35N an excellent choice for various chemical processing applications, oil and gas parts, connecting rods for race cars, orthopedic cables and catheters and orthodontics.

There's also L-605, also known as Haynes 25 (thanks again, Elwood Haynes), which is roughly half cobalt and one-fourth chromium. The cobalt-chromium alloy F75 is commonly used in the electron beam melting (EBM) process, a type of 3D printing, while the Rene family of nickel-cobalt superalloys (with a significant amount of chromium) is a crucial component in many jet engines.

Cobalt, chrome and that other tough nut to crack—molybdenum—are also common alloying elements in many tool steels, such as M42 high-speed steel (HSS) used in taps and drills, bandsaw blades and broaching tools.

Machining Cobalt with Cobalt

Why would anyone use these difficult materials? Their drawbacks are also assets: Their combination of strength, toughness and hardness (up to 70 HRC for M42 tool steel) makes them valuable in a variety of industries where durability is vital.

They exhibit the high-temperature creep strength needed for gas turbine blades, the biocompatibility needed to remain in the human body for years at a time (Biodur is one well-known example), the ductility needed for forming into various shapes and the wear resistance needed for sliding contact under heavy loads.

Despite those qualities, though, cobalt-chromium alloys are indeed machinable—given a rigid setup and the proper feeds and speeds. Here are some tactics that may help:

- Start with a cemented carbide cutting tool or insert that contains a high cobalt percentage for increased toughness. Plan on regular tool changes, preferably before the tool fails.
- PVD coatings like AlTiN and TiAlN can greatly extend tool life in cobalt-chromium alloys. That said, cutting tool manufacturers are constantly developing new, proprietary coatings, so be sure to watch out for the latest advances.
- Want to push the limits? Try polycrystalline diamond (PCD), cubic boron nitride (CBN) and ceramic cutting tools. The first two are relatively expensive and generally limited to finishing operations, while ceramics are changing the game for many shops grappling with difficult cobalt alloys.
- Select a tool with a positive rake angle and sharp edge to reduce cutting forces, but be sure it has the correct edge prep or hone for the operation to avoid chipping. Again, check with your cutting tool provider for recommendations.
- A larger nose radius helps to improve surface finish. If the setup is rigid enough and the part geometry allows, a round insert is even better.
- Following the cutting tool manufacturer's feed and speed recommendations is always good advice, but especially so with alloys high in cobalt, chrome, nickel or molybdenum.
- High feed rates and low depths help to reduce work hardening. So does arcing into and out of corners. Avoid burying the tool, never dwell, and if your CAM system supports it, try varying the depth of cut to spread tool wear across the insert's face.
- Use a high-pressure coolant system with at least 70 bar (1000 pounds per square inch) and through-the-tool coolant. This helps ensure efficient chip evacuation and reduces cutting temperatures, both of which help to extend tool life.
- ***Water-soluble cutting fluids*** are highly recommended (oil may catch fire). Be sure to mix them

properly, maintain the proper coolant concentration and keep them clean and well-filtered.
- Due to the stringy chips produced while machining cobalt-chromium alloys, chip breakers are a must. Positive lead angle tools should be used where part geometry permits, as these leverage the chip-thinning effect for improved tool life.
- It goes without saying that the machining setup should be as rigid as possible. This means high-quality, well-maintained toolholders (preferably shrink-fit, although many high-end hydraulic or mechanical holders do an equally excellent job). A dual-contact spindle interface like Capto or HSK is also beneficial.
- Lastly, balance the toolholder assemblies if spindle speeds exceed 8,000 rpm (good advice in any application).

While these guidelines apply to many machining applications, the stakes are higher and the likelihood of rapid tool failure greater with cobalt and cobalt chrome alloys.

Get Expert Advice from Suppliers

It’s important to adjust the exact parameters and practices, too, based on the alloy you’re working with, the type of machining operation, your CNC machine tool’s capabilities and other machining variables.

Finally, be sure to take small steps when troubleshooting any machining problem. Carefully observe and document tool wear, and don’t wait for the tool to fail before ***changing it out***.

Don’t hesitate to phone a friend. Cutting tool manufacturers employ plenty of smart, experienced people willing to come on-site for a day and lend a hand, as do many machine tool distributors. With superalloys, there’s no reason to go it alone.

What tricks do you use to make machining cobalt easier? Tell us in the comments below.

