viewpoints

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What Is a "Heavy Metal" Machine?

Our company has been quietly involved in an R&D project with a major aerospace company for the last three years to figure out how to design a machine tool to cut the new triple-nickel titanium materials. We, along with makers of cutting tools, have learned a tremendous amount. We are learning more every day—not just how to cut it, you can cut it with a file—but how to cut it with significantly improved productivity and economy. We are building these machines. We are taking orders. But, most importantly, everyone who places an order with us knows full well that perfection of the techniques involved in cutting titanium 5553 is still a work in progress. That's why I must ask questions when I hear a company claim it has the quintessential "titanium" or "heavy metal" machine, and sends its people out to sell it.

In this limited space, I can only present the major areas to discuss when your sales engineer and the "titanium machining expert" come calling:

- Low-frequency machining: The machine tool must have the structural design required to machine at low-frequency, in the less-than 350-Hz range (especially at 20, 90, and 320 Hz). A machine designed specifically for low-frequency machining dramatically reduces chatter at the necessarily low rpm that the cutting tools must utilize to cut these materials. Eliminating chatter significantly increases tool life.
- Tool taper interface: Potential buyers of "heavy metal" machines need to ask this question: What is the moment load that will separate the tool from the spindle tool taper? I'll address this point: On general-purpose machines with a BT/Cat 50 taper, it is 8500 in-lb (960.4 N•m). A 7" (178-mm) long, 1" (25.4-mm) diameter four-flute cutter will remove about 1.2 in.^{3} (19.7 cm^3) of material per minute from 5553 titanium before the tool separates from the spindle taper. If you increase the feed to remove more stock, you will exceed 8500 in-lb. If you want to know how to remove 25 in.^{3} (410 cm^3) of material per minute in 5553—call me.

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- Machine stiffness as defined by Young's modulus of material elasticity: In "heavy metal" machines, all of the materials in the machine tool must stay within a specific range of stiffness in the modulus of elasticity curve. Stiffer machine tool materials cost more, so the machines cost more. The machine must bend consistently when cutting under heavy loads. If it does not, the machine's volumetric accuracy is destroyed, and so is the consistency in the cutting-tool edge contact line—another big key, along with chatter reduction, to increasing tool life.
- Big power: To cut heavy metals, the machine needs ample spindle horsepower, torque, and large servomotor drives on fine-pitch lead ballscrews. These elements will provide the advantages required to push the tool through these tough materials. But, the machine's power mechanisms need to be designed to avoid influencing the low-frequency excitation conditions.

Of course there are several other issues that involve chip control, coolant, the types of cutters, and so on, but the crux of optimum heavy-metal machining lies in those four areas.

Here is the news flash for contract shops: The OEM aerospace companies do not plan on cutting all these special alloy titanium parts themselves. Previously, they would keep these types of proprietary technologies in-house. But now, by my best information, they will rely heavily on their top-tier suppliers. Parts made of Titanium 5553 and about 18 similar grades are coming down the pike. Get ready for them.

For those machine tool companies and sales people who think they have the answers pertaining to cutting 5553, I appeal to you to do your homework. You cannot simply put a geared spindle on an HMC and call it a titanium machine. In the early days of high-speed machining, many machines were sold without the correct capabilities, and our reputations as machine tool vendors were damaged. Let's not repeat this in the "heavy metals" arena. Please educate your customers properly on the true capabilities of your equipment.

Look, I know what Mitsui Seiki has invested in this research, and I know how far we have advanced this technology to date with the help of the biggest, most capable OEM research departments and talents in the industry. There is a tremendous depth of knowledge required for heavy-metal machining. Get the facts.

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