Aerospace

Exceeding Expectations: When the World's Largest Aircraft Manufacturer Invites You to the Table, It's Time to Put Your Best Foot Forward

Brought To You by Kennametal | Sep 03, 2019

It started in 2015, when engineers at a major US-based aircraft manufacturer kicked off a challenge to determine which cutting tool manufacturer offers the best products for milling forged Ti-6Al-4V titanium. The company invited Kennametal and 10 other global tooling suppliers to the University of Sheffield's Advanced Manufacturing Research Centre (AMRC) in the United Kingdom, where the different teams competed in the challenge. The event required months to complete, but the winning tool from Kennametal outperformed its competitors, gave added value in productivity and tool life to the company, and ultimately ended up in the aerospace giant's internal tooling catalog.

Laying Down the Rules

The aircraft manufacturer supplied three sets of cutting parameters for both the "Traditional" milling and "High Velocity" approaches. These were designated as Current, Meets and Exceeds expectations. In the traditional testing rounds a 0.1 in. (2.54 mm) radial depth of cut (DOC) was used, with cutting speeds ranging from 150 SFM (46 m/min) for the "current" values, 200 SFM (61 m/min) for "meets," to 250 SFM (76 m/min) for "exceeds."

"We went straight into the "exceeds" range in the first test round, setting the bar for others to follow," says Kennametal Staff Engineer Danny Davis, who participated in the testing. In the following high velocity testing approach, the DOC was decreased to 0.02 in. (0.508 mm) but with increased surface speeds to 400 SFM (122 m/min), 450 SFM (137 m/min), and 500 SFM (152 m/min), respectively.

Both approaches imposed strict guidelines on tool geometry: participants must use a 1.25 in. (31.75 mm) diameter end mill, one with a flute length of 4 inches (101.6 mm), corner radii of 0.09 in. (2.29 mm), and a flute count of 5 or 6 flutes. "Kennametal was the only participant that dared using a 6-fluted tool right from the start," adds Davis. "We were told 'No Holds Barred!' by management, so we had to start always from the top range." During the testing, tools were required to achieve Z-axis cut depths of 2 inches (50.8 mm), and extend from the holder exactly 4.5 inches (114.3 mm). Only imperial unit tools were allowed (no metric equivalent). It was left to the tooling supplier to determine the tool coating, carbide substrates and best cutting geometry for the test.

An Even Playing Field

Needless to say, engineers at the company provided a clearly defined set of rules for all, and each participant engaged their best and brightest people for the testing. In Kennametal's case, multiple substrates, geometries, coatings and edge preps were evaluated. High and low pressure coolant was tried, sometimes with coolant through the tool, other times without. Kennametal also performed its own internal testing at facilities in Fuerth, Germany and LaVergne, Tennessee, and Asheboro, North Carolina using five different machining centers and filing three patents during this endeavor. Chip flow and formation were analyzed using high speed cameras and new tool grinding processes developed as a result. In all, nearly 300 different tools were produced for the project, and 15,000 cubic inches

(246,000 cm^3) of titanium machined.

The HARVI III from Kennametal outperformed its competitors and is now part of a major aircraft manufacturer's internal tooling catalog.

The results were impressive. During its final round of testing, Kennametal used a shrink fit Safe-Lock™-style holder and operated its tools in the "exceeds" category in all cases. With the traditional milling approach, less than 0.001 in. (0.025 mm) of tool wear was observed after one hour, with a surface finish of 23 µin Ra (0.6 µm). The high velocity approach provided comparable results, with tool wear measured at less than 0.0014 in. (0.035 mm) and surface roughness better than 27.5 µin Ra (0.7 µm). Both met the aircraft manufacturer's requirements, and also delivered a 20% greater metal removal rate than its competitors because Kennametal chose to supply a 6 fute instead of a 5 flute tool.

Moving From the Floor to the Catalog

While the tests were being conducted for the challenge, company engineers were also conducting tests of the Kennametal tools internally, validating them against criteria used for any tools under consideration for production use. They tested multiple tools and were able to run for 2,000 minutes with no more than 0.00157 in. (0.039 mm) wear.

What does this mean to other customers? Kennametal has recently released the results of its months of testing, under a name you might be familiar with. The HARVI III Aerospace Expansion line of solid carbide end mills is based on much of the cutting tool technology that made the HARVI III so popular. It offers six unequally spaced flutes to break up chatter even at higher feed rates. Its lower cutting forces and eccentric relief design provides improved tool life, and has a tapered core that increases stability during heavy cutting conditions. "Interestingly, whatever modifications to the existing HARVI III were tested, we always came back very close to the existing design we've had for the past five years," says Davis. "The final modification was so minor that we plan to simply upgrade the old HARVI III design."

The new HARVI is available in KCSM15 Beyond grade, which is designed for exceptional performance in titanium and stainless steels, and its center cutting design gives you the flexibility to use it for roughing and finishing operations alike. "In total, 303 standard catalog line items were created," Davis notes. "This includes ball nose and square end mills with various radii in different overall lengths. The standard offering comprises diameter ½ in. up to 1¼ in. off the shelf and even 1½ in. made-to-order with very short lead times. This illustrates how serious we take the new product line, which is much larger than any HARVI line launched in the past."

"The HARVI III Aerospace Expansion line is now part of the aerospace leader's internal tooling catalog," adds Kennametal Key Account Manager Peter Lawson. "That's good for them, but it's even better for those shops that struggle to achieve tool life in titanium, who can now leverage the results of our combined testing. The HARVI III line not only produces more parts, more predictably and in less time

than the competition, it also offers better chip control and tool life, a win-win for any shop. It was both a privilege and an honor to be chosen for this competition, and it's gratifying to deliver a product that perfectly addresses so many of our customers' needs."

To learn more about the HARVI III line of solid carbide end mills and browse the different mill diameters available, go to MSCDirect.com.