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Real-Life Stories

Grinding Versus Machining in Aerospace Applications

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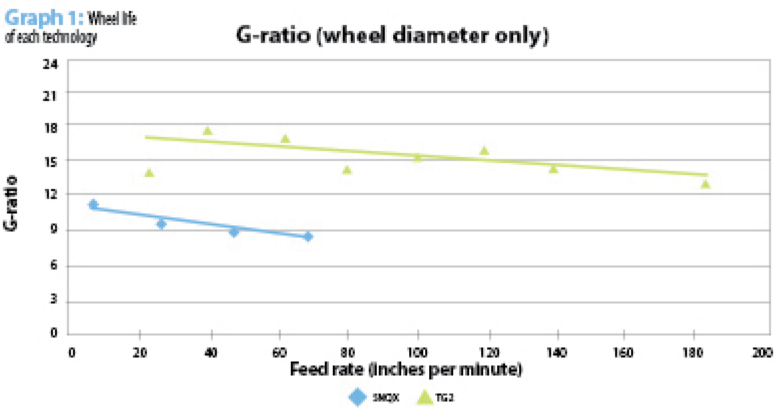
The aerospace industry is known for using materials that defy machining with conventional tools and processes. The properties of these materials – high-strength at high temperature that allows the components to survive in the hostile environment of an aerospace engine – are the same attributes that make them difficult to machine.

Whether the parts are cast, forged, or made from sintered powdered metal, most have 50% or more of their original volume removed before turning, milling, and broaching. Because of the properties of these materials and the high value of the parts, these operations are usually run at conservative feeds and speeds to ensure the tools don't fail or damage the part.

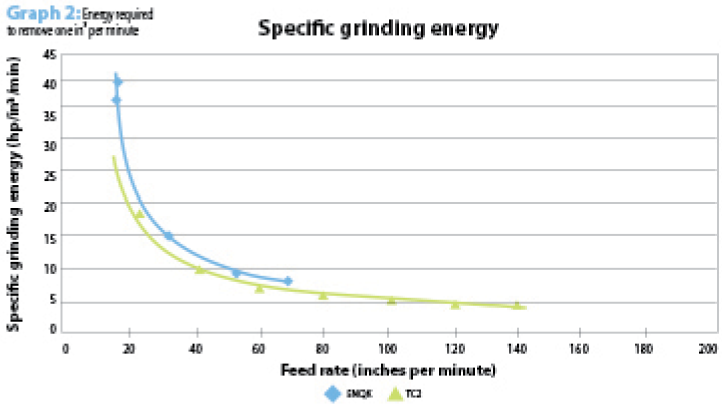
Regardless of the parameters used in machining, part tolerances and surface quality degrade as the tool wears, which can reduce the component's life in the engine. In contrast, a grinding wheel is easily dressed – keeping the cutting edges of the abrasive sharp and the wheel shape constant, which in turn results in consistent finishes and close tolerances.



Aerospace slotting

An aerospace customer needed to cut slots into a disk of IN718 material and wanted to compare a milling process with grinding. The customer turned to engineers at Norton | Saint-Gobain Higgins Grinding Technology Center who conducted an evaluation with two abrasives: one with Norton Targa ceramic aluminia TG2 grain and the other Norton Quantum ceramic alumina 5NQX grain.

Two plates of IN718 were stacked and four, 1/2" wide slots were ground 1/2" deep for each condition without dressing the wheel. A depth of cut of 0.100" was arbitrarily selected and feed increased in increments of 20"/min. until wheel wear was deemed too high. In the case of the 5NQX wheel, a feed rate of 70ipm was reached before wheel wear was deemed too high, and for TG2 wheel, the feed was increased to 180ipm. Graphs 1, 2, and 3 show the G-ratio (volume of material removed ÷ volume of wheel loss), energy to remove one in3 per minute, and a removal rate comparison by different end mills for the application.

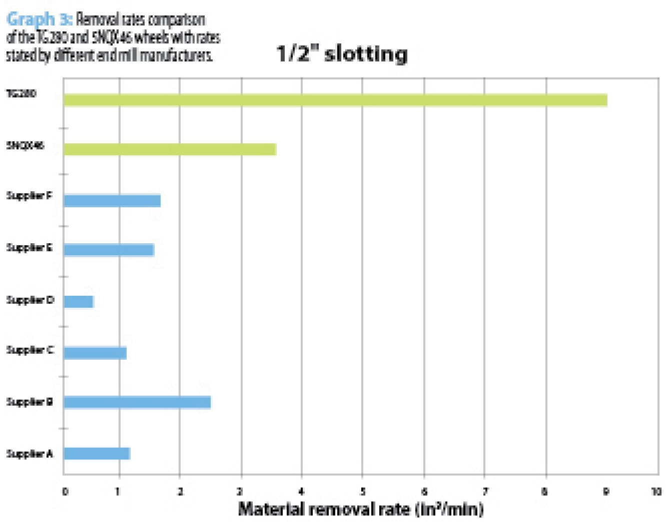


Graph 2: Energy required to remove one in³ per minute

Aerospace turning

Replacing a traditional process with grinding depends more on how the part and wheel contact each other than on geometry. Similar to the slotting case, another example uses wheel technology, replacing the turning operation with grinding.

Newer nickel alloys used in aerospace can be even more difficult to machine than legacy materials such as IN718. A customer was having difficulty with turning one of these new nickel alloy materials. Inclusions in the material were causing unpredictable tool failure and tool life was very low due to the high strength of the material. Using Norton Vitrium3 bond along with the extruded TG2 grain, Norton engineers were again able to grind the part at a feed of 0.025" per part revolution and a work speed of 160ipm, reaching a removal rate of 4.0in³/min/in. Under these conditions, 8.0in3/min were removed using a 2" wide wheel. With the tool change capabilities in today’s machines, separate wheels can be used to reach and finish complex part geometries the same way as a traditional CNC lathe. If the surfaces require grinding after turning, then the turning operation can be eliminated.



Graph 3: Removal rates comparison of the TG280 and 5NQX46 wheels with rates stated by different end mill manufacturers.

Cost savings on manufacturing processes can come from reduced capital expenditure, consumable tooling, logistics, or cycle-time reduction. Engineers can now identify opportunities where an abrasive solution will outperform traditional machining processes, and using advanced abrasive products and documentation software, can help identify and deliver savings to your operation.

ASSUMED MILLING PARAMETERS

Milling – carbide endmill								
Tool	DOC	dia.	sfpm	rpm	ipt	teeth	ipm	in³/min
Supplier A	0.5"	0.5"	100	764	0.0015	4	4.6	1.15
Supplier B	0.5"	0.5"	162	1,238	0.0020	4	9.9	2.48
Supplier C	0.5"	0.5"	60	458	0.0025	4	4.6	1.15
Supplier D	0.5"	0.5"	67	512	0.0010	4	2.0	0.51
Supplier E	0.5"	0.5"	105	802	0.0018	4	5.8	1.44
Supplier F	0.5"	0.5"	200	1,528	0.0010	4	6.1	1.53

As the test results support, grinding proved to be the most effective, productive material removal process.

Previously featured on Norton Abrasives.