FOCUS: SUPERABRASIVES

SuperBond

Advantages of phenolic-resin bonds for superabrasive grinding wheels.

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The mantra of modern machining is to run faster in order to remove the most material possible in the shortest amount of time. For many, diamond grinding wheels with thermoplastic, or polyimide, bonds are the "weapon" of choice for high-volume production of carbide cutting tools.

However, superabrasive grinding wheels utilizing a special bond formulation of phenolic resin can offer faster stock removal and additional benefits not found in traditional polyimide-bond wheels. In some cases, the cycle time when deep fluting can be cut by 50 percent or more, which translates into significant savings and increased output. At the same time, part quality is maintained at the highest level.

Phenolic vs. Polyimide

The use of phenolic-resin-bond wheels is growing among manufacturers of carbide cutting tools, especially in those areas where polyimide-bond wheels had been the benchmark. These include creep-feed grinding and fluting of round, solid-carbide tools.

A phenolic bond is formulated so it couples free-cutting, high-stock removal characteristics with excellent form-holding attributes. This allows phenolic wheels to produce tight-tolerance part geometries while allowing feeds that are nearly double those possible with high-performance polyimide wheels.

The phenolic-resin-bonding process is performed at a much lower temperature than the temperature at which polyimide bonds are produced. The lower temperature allows the bond to be formulated with performance-enhancing additives, such as those for lubrication and that improve heat removal.

The formulation can be tailored for a specific application or system, such as an oil-based grinding system. Oil-based fluids, which are used predominantly when grinding carbide round tools, are known to have superior lubricity with moderate heat-removal capabilities. The phenolic-resin wheel can be formulated with special heat-removal additives and an open porosity to complement the characteristics of oil-based fluids. Such a formulation helps draw the heat and chips away from the wheel/workpiece interface.

Performance Issues

Phenolic bonds, compared to polyimide bonds, allow wheels to grind faster while imparting a finer finish and producing a higher-quality edge. The use of state-of-the-art grinding equipment further enhances the performance of

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A phenolic-resin wheel can be formulated with special heat-removal additives and an open porosity to complement the superior lubricity and moderate heat-removal characteristics of an oil-based fluid.

phenolic wheels.

Another advantage of phenolic wheels is they cost less. Furthermore, polyimide wheels need to be run on high-horsepower, high-torque machine tools with sophisticated coolant-delivery systems in order to perform at their best without burning or stalling. Phenolic wheels' enhanced lubricity and advanced structure allow them to grind cooler and faster across a range of equipment.

Traditionally, it has been difficult to manufacture a tough form-holding bond that also is fast in the cut. In the never-ending push for higher-quality cutting tools, many toolmakers select wheels with finer grit sizes to achieve smoother finishes and higher edge quality. Often, cycle time and the grinding ratio—the amount of material removed from the workpiece vs. the amount of wheel wear—are significantly compromised in an attempt to increase overall tool quality. Phenolic-resin wheels overcome this contradiction of grinding by holding the wheel's form and providing a high grinding ratio while imparting fine surface finishes and machining at a high metal-removal rate.

The use of superabrasive wheels with phenolic-resin bonds is growing among manufacturers of carbide cutting tools.

Test Results

In a technical research laboratory, processes and techniques are developed and tested on many different types of grinding machines. But the most convincing results are those achieved by actual end users.

One test conducted by an end user involved fluting a 0.5"-dia., 4-flute carbide endmill with a flute length of 1.5". A polyimide wheel run at a feed rate of

PRODUCT	TOOL DIAMETER (INCHES)	NUMBER OF FLUTES	FLUTE LENGTH (INCHES)	DOC (INCHES)	FEED RATE (INCHES)	CYCLE TIME (IPM)
TEST #1 Polyimide bond Phenolic bond	0.375	2	1.5	0.150	1.25 3.5	12 min., 27 sec. 6 min., 10 sec.
TEST #2 Polyimide bond Phenolic bond	0.5	2	1.5	0.120	3 8	13 min. 6 min., 5 sec.
TEST #3 Polyimide bond Phenolic bond	0.5	4	1.5	0.125	4 9	7 min., 49 sec. 4 min., 13 sec.
TEST #4 Polyimide bond Phenolic bond	0.675	4	2	0.150	1.5 5	12.5 min. 7.5 min.
TEST #5 Polyimide bond Phenolic bond	0.75	4	3	0.150	1.5 3.5	20 min. 14 min.
TEST #6 Phenolic bond	1	4	2.5	0.250	3	6 min., 16 sec. (fluting only)

Table 1: Test results comparing polyimide-bond wheels and phenolic-resin-bond wheels.

Compared to polymide-bond wheels, the enhanced lubricity and advanced structure of phenolic-bond wheels allows them to impart finer surface finishes and produce a higher-quality edge.

4 ipm yielded a cycle time of almost 8 minutes per tool. Grinding the same part, a phenolic wheel was run at a feed rate of between 8 and 9 ipm, decreasing cycle time by 50 percent while imparting a finer surface finish. There was no distinguishable difference in wheel wear.

Internal tests results, combined with various customer application trials in the field, support the superiority of phenolic-resin bonds for grinding a variety of tool diameters (Table 1). All tests were conducted on modern CNC grinding machines using an oil-based coolant to grind solid-carbide blanks, including standard C-2 carbide and harder-to-grind carbide with titanium carbide and tantalum carbide inclusions.

This consistently high level of performance saves significant time and money. When grinding is conducted at established machining parameters, phenolic-resin wheels are capable of producing tools in unattended, "lights out" machining environments, further driving down costs.

The pressure is on to continually reduce costs while producing higher quality cutting tools. By developing advanced superabrasive wheels and offering appropriate application parameters, manufacturers of grinding wheels are able to help decrease their customer's cutting tool production costs.

About the Authors

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