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DIAMOND PRODUCTS

Preparation of Diamond Grinding Wheels

Truing and Conditioning Your Diamond Grinding Wheel

(Source: Superabrasives – Grinding and Machining with CBN and Diamond – By S.F. Krar and E. Ratterman)

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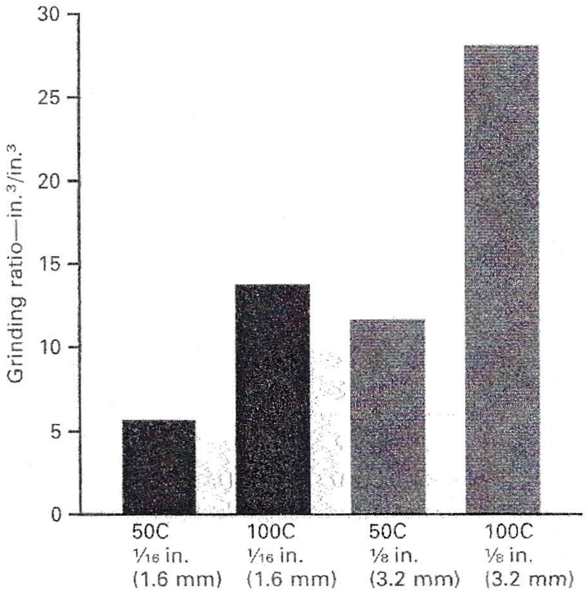

Fig. 8-11 A sixfold improvement in grinding ratio can result if diamond depth and concentration are combined. *(Courtesy of GE Superabrasives)*

WHEEL MOUNTING AND PREPARATION

Care should be taken whenever a diamond wheel is mounted because it pays off in longer wheel life and consistent accuracy in the parts ground. For a diamond wheel to grind at 100 percent efficiency, the wheel must run as true as possible.

Runout of a diamond wheel will cause it to chip on the edges, wear faster, produce poor surface finishes, and produce inaccurate parts. Wheels where the outside diameter is used for grinding should never run out more than 0.0005 in. (0.01 mm). Cup grinding wheels should never run out more than 0.0005 in. (0.01 mm) on the grinding face. Careful attention in mounting the wheel will reduce initial wheel loss due to truing and dressing—or even eliminate this loss. Chapter 5, on preparing the CBN wheel and grinder, deals extensively with the mounting, truing, and dressing of CBN wheels. Many of the same points apply to diamond wheels; therefore, it is wise to refer to Chapter 5 before mounting, truing, and dressing diamond wheels.

The following is a summary of the key points which must be followed when mounting a diamond wheel if it is to perform satisfactorily:

1. The diamond wheel should be mounted on a high-quality adapter and should be kept together as a unit for the life of the wheel.
2. Mount the wheel-adapter unit on the grinder spindle and lightly tighten the flange nuts.
3. Check the runout on the grinding portion of the wheel with a dial indicator and correct the runout by:
   a. *Wheel Circumference.* Move the wheel on the adapter by gently tapping with a hammer on a wooden or plastic block until the runout is no more than 0.0005 in. (0.01 mm) (Fig. 8-13).
   b. *Wheel Face.* Face wheels are usually trued by the manufacturer and should have very little runout. If a runout greater than 0.0005 in (0.01 mm) is indicated, the wheel must be trued (Fig. 8-14).
4. Tighten the flange nuts securely and recheck the wheel runout.

Wheel Preparation

The condition of the grinding surface of a diamond wheel will determine the success or failure of any

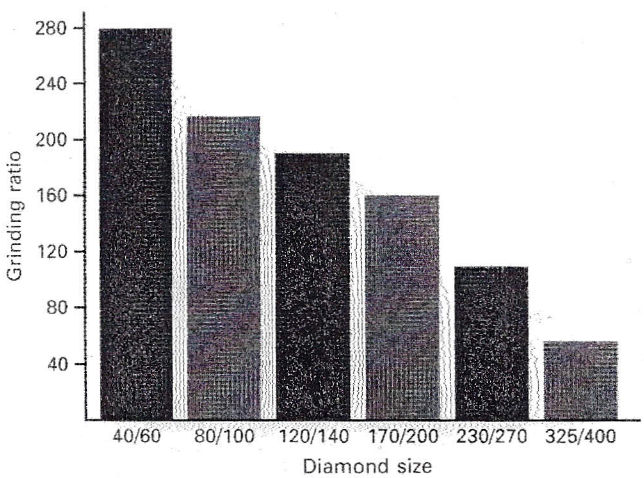

Fig. 8-12 Using the coarsest grit size possible results in the lowest grinding wheel cost per piece. *(Courtesy of GE Superabrasives)*

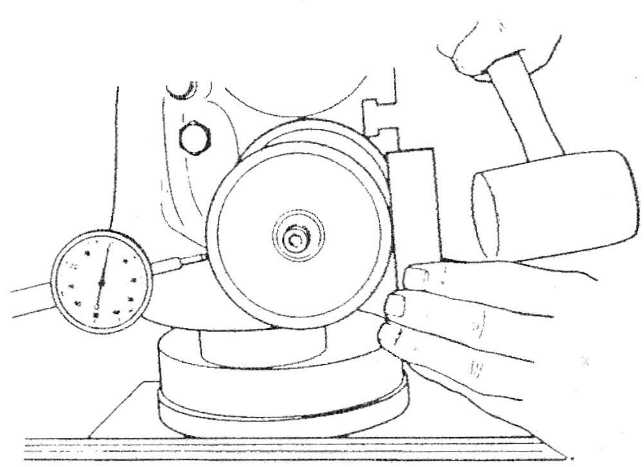

Fig. 8-13 Correcting the runout on the circumference of a diamond grinding wheel. *(Courtesy of Cincinnati Milacron Co.)*

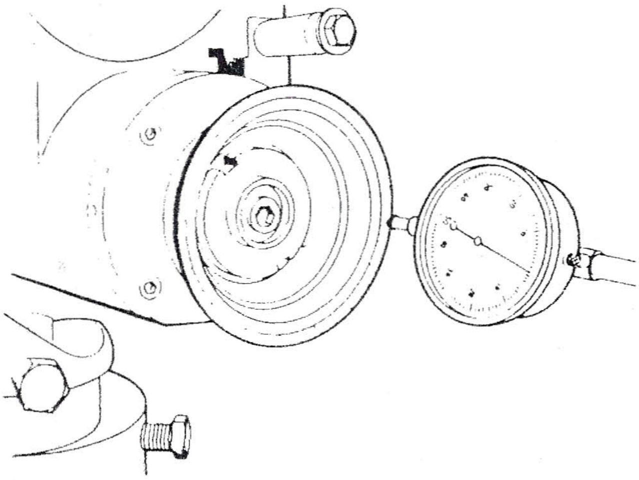

Fig. 8-14 Checking the runout on the face of a diamond cup wheel. *(Courtesy of Cincinnati Milacron Co.)*

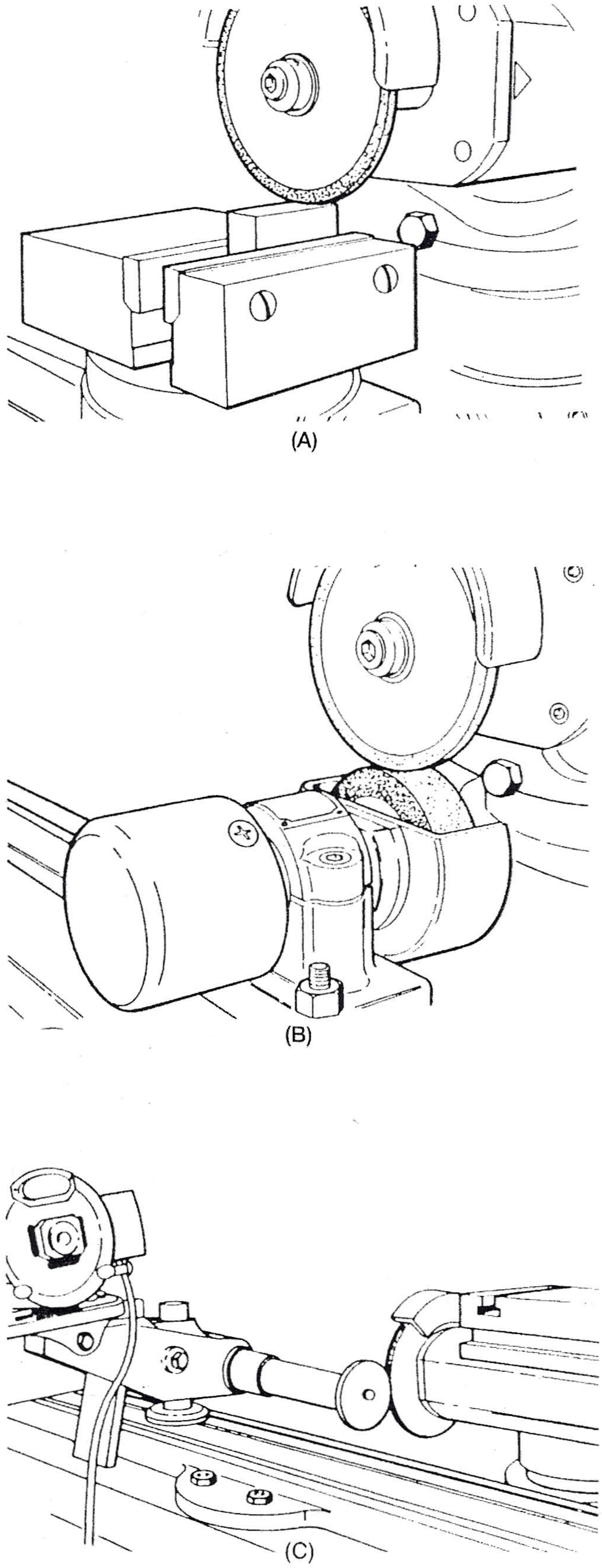

Fig. 8-15 (A) Mild steel block. (B) Brake-type dresser. (C) Toolpost grinder. *(Courtesy of Cincinnati Milacron Co.)*

grinding operation. Wheel conditioning, next to speeds and feeds, is the most important factor in the efficient use of diamond wheels. This can involve the operations of truing and dressing. For best performance, grinding wheels should be trued anytime they are removed from the grinder.

Truing

If the wheel runout is more than 0.0005 in. after mounting, it will be necessary to true the wheel. Truing consists of grinding or wearing away a portion of the abrasive section of the grinding wheel to make it run true or to bring it to the desired shape. Chapter 5 covers the operations of truing and dressing of CBN wheels in detail and should be followed for diamond wheels. The major difference between the two wheels will be that the diamond wheel is much harder and therefore will take longer to true and dress than is necessary for a CBN wheel.

Some of the more common methods of truing a diamond wheel are:

1. *Mild Steel Block* (Fig. 8-15A)
   a. Mount a mild steel block on the grinder.
   b. Take a few passes across the steel block at 0.001-in. (0.02-mm) depth per pass.
   c. Stop the grinder and check the wheel face or circumference for truth with a dial indicator.
   d. If necessary, continue passes over the steel block until the wheel runout is eliminated.
2. *Brake-Type Dresser* (Fig. 8-15B)
   a. Mount a brake-type dresser on the grinder.
   b. Follow the dresser manufacturer's recommendations on the use of this equipment.
   c. Continue the operation until the wheel runout is corrected.

3. *Toolpost Grinder* (Fig. 8-15C)
   a. Mount a toolpost grinder on the grinder table.
   b. Mount an 80- to 120-grit vitrified silicon carbide wheel on the grinder spindle to operate at about one-quarter of its normal speed.
   c. Set the diamond wheel and the silicon carbide wheel to operate in opposite directions.
   d. Take a few passes at 0.001 in. (0.02 mm) over the diamond wheel.
   e. Check the wheel for runout with a dial indicator.
   f. Continue taking passes over the diamond wheel until the runout is corrected.

Dressing

The truing process generally leaves the grinding surface of a diamond wheel smooth, with few or no abrasive crystals protruding above the wheel surface. A wheel in this condition would burn the workpiece and remove little or no work material. Dressing removes some of the bond material from the surface of a trued wheel to expose the diamond crystals and make the wheel grind efficiently.

To dress a diamond wheel:

1. Select a silicon carbide or aluminum oxide dressing stick.
2. Saturate the dressing stick with coolant so that a slurry is created when it contacts the diamond wheel.
3. Hold the dressing stick firmly and bring it into contact with the revolving diamond wheel (Fig. 8-16).
4. Feed the dressing stick aggressively into the wheel to open up the wheel face.
5. Once the dressing stick starts to wear rapidly, the diamond wheel is dressed.

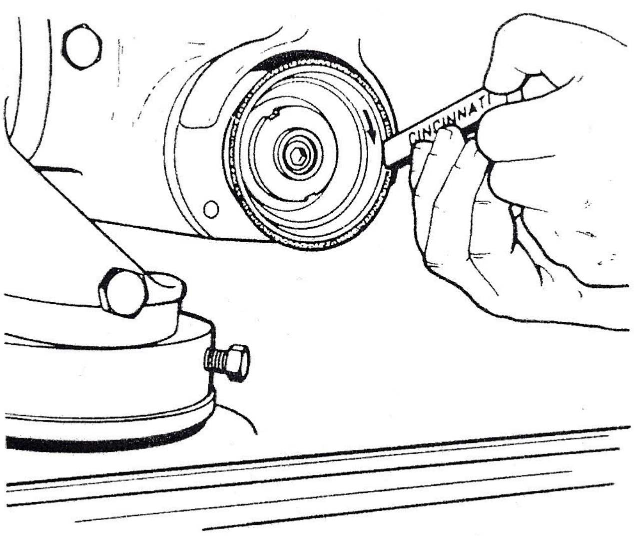

Fig. 8-16 Opening up the face of a diamond grinding wheel with a silicon carbide dressing stick. *(Courtesy of Cincinnati Milacron Co.)*

USING DIAMOND WHEELS

The proper use of diamond grinding wheels will result in long wheel life and high material-removal rates. To achieve the best grinding performance, the diamond wheel must be used under conditions which make this possible. Operating conditions such as wheel speed, work speed, feed rate, and the use of coolant are factors which affect the performance of a diamond grinding wheel.

Wheel Speed

In wet surface grinding, the speed of a diamond wheel is important to the grinding performance. Low wheel speeds (below 4000 sf/min) tend to reduce grinding efficiency, while speeds (over 6000 sf/min) tend to reduce wheel life. The best average wheel speed for most applications is in the 4000 to 6000 sf/min (20 to 30 m/s).

The best wheel speed for dry tool and cutter grinding is 3500 sf/min (18 m/s), using medium to fine grit sizes (150 and finer) at 75 or 100 concentration. Many tool and cutter grinders are set to drive a wheel at 3500 to 4500 sf/min (18 to 23 m/s). *Do not dry grind at wheel speeds over 4500 sf/min (23 m/s).* Dry grinding at speeds over 4500 sf/min (23 m/s) will cause heat damage to the diamond wheel. If it is absolutely necessary to operate at above 4500 sf/min (23 m/s), a coolant should be used to prevent damage to the wheel and extend its life.

Work Speed

Table traverse speed or crossfeed is largely governed by the amount of downfeed or depth of cut. Because these can vary greatly depending on the machine condition, grinding operation, workpiece material, and other factors, it is difficult to give specific work speed rates. The best work speed, often arrived at through trial and error, is where there is no loss of wheel speed, excessive wheel wear, or damage to the wheel or work.

Feed Rate

Excessive feed or depth of cut will shorten the life of a diamond grinding wheel and should be avoided. Too deep a cut can result in burned and cracked wheels, chipped or cracked carbide, and failure to obtain part size, finish, and form.

In face grinding cemented carbides, trying to take a heavy cut too quickly will result in the carbide acting as a shear and dressing the diamond wheel face. When grinding on the periphery of the wheel, heavy cuts cause the wheel to climb the workpiece, causing the work to dress the wheel out of round and producing chatter.

The depth of cut possible with diamond wheels is governed by the diamond grit size. The recommended depths of cut for various diamond wheel grit sizes are listed in Table 8-4. Feeds more than those recommended will cause material of the part to get under and cut away many diamond grits per revolution that will never get a chance to cut.

Cutting Fluids

Cutting fluids should be used whenever possible when using diamond wheels to reduce the grinding heat and extend the wheel life. If it is necessary to grind dry, as in tool and cutter grinding, a resin-bond wheel should be used. Sometimes spray mist with a rust inhibitor or refrigerated air can be used as a coolant to reduce the grinding heat; however, this is not as effective as wet grinding.

A small trickle of coolant occasionally applied is worse than no coolant at all. This causes alternate heating and quenching, which can cause damage to the diamond wheel and carbide tools. The best way to apply coolant is to allow the centrifugal force of the wheel to deliver it in a steady stream to the point of grinding contact (Fig. 8-17).

Today, there is a wide range of resin-bonded grinding wheels which have been specifically designed to be used dry when grinding cemented carbide tools. These wheels are very effective and maintain productivity without the use of any coolant.

Carbide Grinding Economics

When grinding cemented carbides with diamond wheels, two sets of costs must be considered—labor and overhead cost per piece and diamond wheel cost per piece. Labor and overhead cost per piece can be reduced by increasing the material-removal rate. This increases the diamond wheel cost per piece since diamond wheel wear increases with the material-removal rate.

Generally, the economic material-removal rate—the rate at which labor and overhead cost per piece and wheel cost per piece are balanced for lowest total grinding cost—is quite low when grinding cemented carbides in comparison with steel grinding. For dry tool and cutter grinding, the optimum material-removal rate is seldom more than 1 to 2 in.^{3} (16.4 to 32.8 cm^3) of cemented carbide per hour. For wet surface, cylindrical, and vertical spindle grinding, the optimum material-removal rate usually ranges from 2 to 10 in.^{3} (32.8 to 164 cm^3) of cemented carbide per hour.

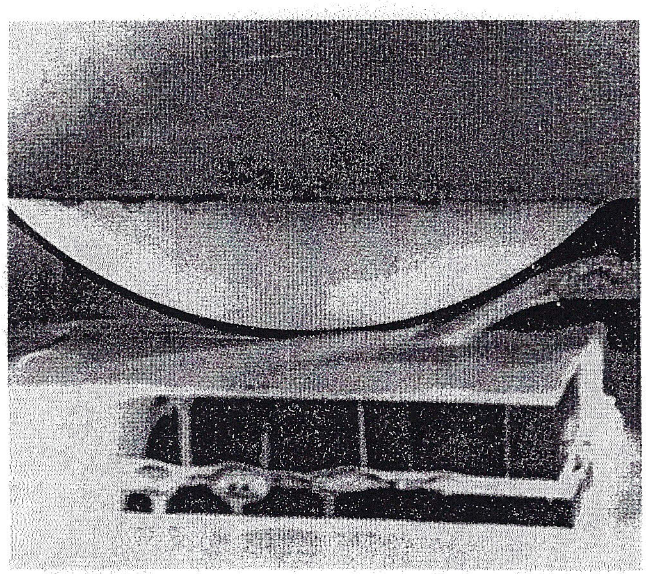

Fig. 8-17 A flood coolant directed to the grinding zone can increase wheel life ten times over dry grinding. *(Courtesy of GE Superabrasives)*

To realistically evaluate the economics of cemented carbide grinding operations, it is necessary to know how well the wheel is performing. A useful index of diamond wheel performance is the *grinding ratio.* The grinding ratio is obtained by dividing the volume of workpiece material removed in a given time by the volume of wheel consumed in the same period, when operating under constant conditions. The higher the grinding ratio, the longer the life of the wheel (Fig. 8-18).

Material-Removal Rates

With the right wheel for the job, running at the right speed, a variety of material-removal rates are possible. Low material-removal rates extend wheel life at

Table 8-4 RECOMMENDED DEPTH OF CUTS FOR DIAMOND GRIT SIZES

Diamond Grit Size	Grit Diameter		Recommended Maximum Depth of Cut	
	in.	mm	in.	mm
100	0.006	0.15	0.002	0.05
150	0.004	0.10	0.0015	0.04
220	0.003	0.08	0.0008	0.02
400	0.0015	0.04	0.0004	0.01

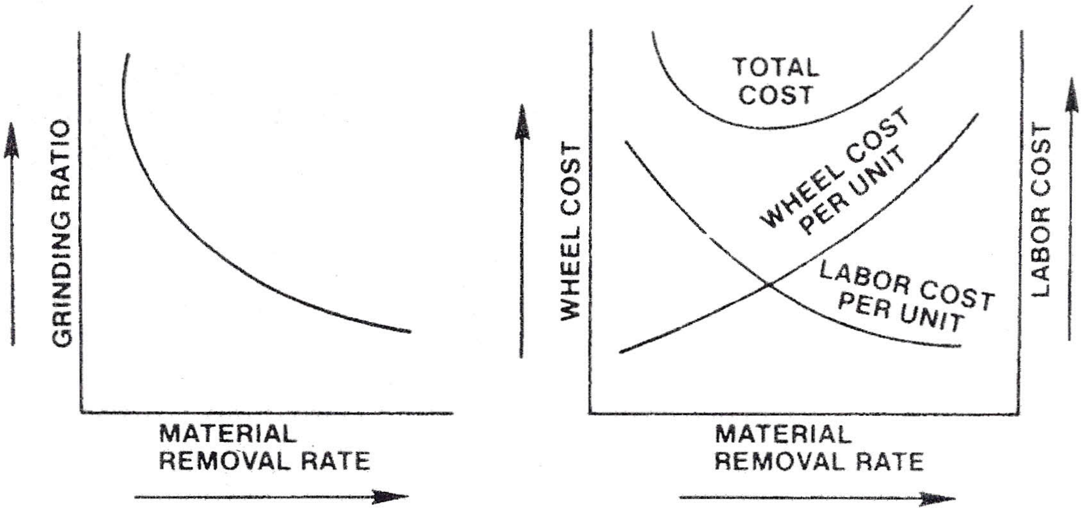

Fig. 8-18 Grinding-wheel life is reduced as material-removal rates are increased when grinding cemented carbides. *(Courtesy of GE Superabrasives)*

the expense of productivity. High material-removal rates increase productivity at a sacrifice of some wheel life. In most industries, material-removal rates are selected on the basis of least total grinding cost per piece. Generally, this is at a point where wheel cost per piece and labor-and-overhead cost per piece are approximately equal.

There is no clearly defined method of increasing material-removal rate that will guarantee the most effective use of the diamond grinding wheel. Laboratory tests have indicated that in both wet and dry grinding cemented carbides, the life of the wheel is shortened in some direct relationship to the increase in material-removal rate, irrespective of the technique employed for increasing removal rate. However, there is some indication that in the case of wet surface grinding the use of heavy crossfeeds will take a somewhat lesser toll in wheel life than will downfeed or table speed.

However, a very important factor to consider is that the wheel is removing carbide only while the wheel and the workpiece are in contact. Any technique which increases the noncontact time between the wheel and the workpiece diminishes the effective material-removal rate and increases cost.

Wheel Life

The life of a diamond grinding wheel can be affected by the wheel speed, the work speed, the depth of cut, the grinding mode, the area of wheel contact, and the type of carbide ground. All these factors have an effect on the forces which are created during the grinding process.

Three forces act on a diamond wheel in tool and cutter grinding of cemented carbides: normal force, tangential force, and radial force (Fig. 8-19). *Normal force* is by far the greatest of the three forces which act on a wheel. Increasing the infeed (depth of cut) from 0.002 to 0.004 in. (0.05 to 0.10 mm) reduces the wheel life because the increased pressure will cause the wheel to break down more quickly. The three forces are interrelated, and the specific grinding conditions will determine the amount of each force component.

TOOL AND CUTTER GRINDING GUIDELINES

The tool and cutter grinder is the most common machine tool used for regrinding or reconditioning carbide and high-speed steel-cutting tools. This machine is versatile and provides the operator with a good view of the sharpening operation. For best results in regrinding cutting tools, the following guidelines are offered:

1. *Reduce the Area of Contact.* The contact surface on the wheel face should not be much more than ⅛ in. (3 mm) wide. Narrow wheel rims are suitable for most grinding jobs. Although wider wheel rims give longer wheel life, they create more grinding heat.
2. *Use Low Wheel Speeds.* Wheel speeds should be around 3500 sf/min (18 m/s) for dry grinding operations in order to reduce the heat created at the cutting tool edges.
3. *Use Reduced Work Speed.* The table speed should not be more than 6 to 9 ft/min (2 to 3 m/min) to reduce the possibility of diamond grit being torn out of the wheel due to crowding. Diamond wheels will perform better with deeper infeeds and slower work (table) traverse speeds.
4. *Depth of Cut.* The depth of cut is governed by the diamond grit size. For a 100-grit diamond wheel, the maximum depth of cut should be 0.002 in. (0.05 mm) and 0.0004 in. (0.01 mm) for a 400-grit wheel.