DIAMONDS AREN'T FOREVER

The proper use of diamond blades is critical to providing cost-effective solutions for the construction industry.

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Diamonds are well recognized as the hardest substance known to man. One would think that an operator of a sawing machine could utilize the hardness characteristics of diamonds to maximum advantage, i.e., the harder the better. In practice, this is not always true.

Whether the operator is cutting or drilling concrete, stone, masonry or asphalt, the diamonds must wear in order to maximize the performance of the cutting tool. This article examines the role diamonds play in cutting tools and how an operator can effectively use diamond cutting tools thereby increasing productivity and maximizing the life of the tool.

Diamond Shape and Size Diamond crystals can be synthetically grown in a wide variety of qualities, shapes and sizes. Synthetic diamond has replaced natural diamond in virtually all construction applications because of the ability to tailor-make the diamond for the specific application.

Diamond shapes can vary from tough blocky cubo-octahedral crystals to more friable crystals with less well-defined geometry. Diamond crystals with blocky shapes and sharp edges are generally better suited for stone and construction applications. The blocky shape provides greater resistance to fracturing, and thus provides the maximum number of cutting points and minimum surface contact. Lower-grade diamonds are less costly, generally have more irregularly shaped and angular crystals, and are more suited for less-severe applications.

The size of the diamond crystals, as well as the concentration, determines the amount of diamond that will be exposed above the cutting surface of the segments on the blade. The exposure, or height, of diamond protrusion influences the depth of cut of each crystal, and subsequently, the potential material removal rate. Larger diamond crystals and greater diamond protrusion will result in a potentially faster material removal rate when there is enough horsepower available. As a general rule, when cutting softer materials, larger diamond crystals are used, and when cutting harder materials, smaller crystals are used.

Diamond Impact Strength All diamonds are not the same, and this is especially true for the strength of diamonds used in construction applications. Other diamond-related factors, such as crystal shape, size, inclusions and the distribution of these crystal properties, play a role in the impact strength.

In general, a greater impact strength is required for more demanding, harder-to-cut materials. However, using higher impact strength diamond that is more expensive will not always benefit the operator. It may not improve, and may even degrade tool performance.

How Diamond Tools Work A diamond saw blade is composed of a circular steel disk with segments containing the diamond that are attached to the outer perimeter of the blade. The diamonds are held in place by the segment, which is a specially formulated mixture of metal bond powders and diamond, that have been pressed and heated in a sintering press by the manufacturer. The diamond and bond are tailor-made to the specific cutting application. The exposed diamonds on the surface of the segment do the cutting.

Contrary to a popular advertising campaign, a diamond is not forever. The exposed diamond cutting points eventually wear away, and if not for some provision to replace these cutting points, the blade or bit would soon be useless. This process is actually desired as it exposes a new layer of diamond crystals underneath to continue the cutting action.

The life of a cutting diamond starts as a whole crystal that becomes exposed through the segment bond matrix. As the blade begins to cut, a small wear-flat develops and a bond tail develops behind the diamond. Eventually, small microfractures develop, but the diamond is still cutting well. Then the diamond begins to macrofracture, and eventually crushes. This is the last stage of a diamond before the diamond pops out of the bond. The blade continues to work as its cutting action is taken over by the next layer of diamonds that are interspersed throughout the segment.

The metal bond matrix, which can be made of iron, cobalt, nickel, bronze or other metals in various combinations, is designed to wear away after many revolutions of the blade. Its wear rate is designed so that it will wear at a rate that will provide maximum retention of the diamond crystals and protrusion from the matrix to ensure optimum cutting.

The diamond and bond work together and it is up to the manufacturer to provide the best combination based upon the specific cutting requirements. Critical factors include the bond system, material to be cut and machine parameters. The combination of diamond and bond accomplishes a number of critical functions:

- Separation and support for the diamond
- Control of the segment wear rate
- Introduction of new diamond cutting points
- Optimum diamond retention
- Distribution of the impact load of the diamond as it grinds

Segment Attachment It is important for the operator to understand that different methods are utilized to attach the diamond segments to the steel core. Two of the more popular methods utilized today include brazing and laser welding. Because of the lower melting temperature of the solder used in the brazing process, braze-welded blades should not be operated dry.

Blade Operating Speeds Manufacturers produce blades for specific applications. They recommend operating speeds or a maximum operating speed for that blade and print this information directly on the blade. Recommended operating speeds are based on blade size, equipment type and the type of material being cut. Maximum operating speeds are set by the American National Standards Institute (ANSI) Code B7.1. Never operate a blade above the maximum or "Do Not Exceed" rpm stamped on the blade. Failure to comply with this warning is dangerous and can result in injury or death.

The optimum operating speeds for cutting concrete have been found to be around 10,000 surface feet per minute, or the surface speed of the diamond cutting segments on the periphery of the blade.

It is important for the operator to maintain appropriate operating conditions to maximize blade performance. For optimum blade life and cutting speed, the actual operating speed will most likely have to be adjusted for the type of aggregate and the amount of steel encountered. In general, higher operating speeds make the blade act harder and tend to lengthen blade life, but slow the cutting. Decreasing blade speed will make the blade act softer, but blade life will also decrease.

When in doubt about the correct operating speed for a particular material, it is better to choose a lower speed rather than a higher speed. Once the blade is cutting well, the speed can be increased to optimize life of the diamond blade. When cutting softer abrasive materials at a faster peripheral speed, a faster forward traverse rate and more water should be used.

Depth of Cut The depth of cut should be adjusted so that a forward speed for a saw of 8 to 10 FPM (feet per minute) can be maintained while cutting concrete. Coolant water or some other coolant must be used to cool most diamond blades. If not enough water is used, the swarf (material that has been removed) will not be removed from the cut quickly. This is a common, but not the main cause, of undercutting where the abrasive particles from the cut wear away the steel core just below where the diamond segment is attached to the steel core. Without sufficient water, the core will also overheat, causing cracks and premature loss of segments. To minimize blade wear, an adequate volume of water is essential. The water flow for cooling saw blades should be between 1.3 and 2.6 gallons per minute.

Machine Drive Power Another factor to consider when optimizing the cost-effective use of any blade is the amount of power available to a blade. This also has an effect upon tool performance. Operating a machine with less power than is required can result in blades that will polish or glaze over, resulting in slow cutting speeds.

Machine power requirements for typical concrete cutting machines are:

- Core Drills: 2 to 20 horsepower
- Flat Saws: 8 to 100 horsepower
- Wall Saws: 10 to 35 horsepower
- Wire Saws: 10 to 50 horsepower

In order for a saw blade manufacturer to provide the proper cutting tool, it is necessary to know the maximum horsepower of the machine. Generally, but not always, blades with soft bond segments will break down faster if used with high-horsepower equipment. On the other hand, blades with hard bond segments cut better when used on high-horsepower equipment.

Diamond cutting tools require that pressure be applied for maximum performance. Sufficient pressure must be applied to maintain sharp cutting crystals. If too little pressure is applied, the diamond crystals are likely to become dull and polish. Conversely, too much pressure can also damage the diamond cutting tool.

Material to Be Cut Knowing as much as possible about the concrete can be of enormous benefit to the cutting operator and the tool manufacturer. Before a manufacturer can recommend a blade, he or she must know the type of aggregate that is to be cut as well as whether reinforcing steel will be present, and the depth of cut. Limestone, slag and coral aggregate are relatively soft and abrasive, providing little problem for the diamond blade to cut. Concrete with river gravel or quartzite aggregate is of medium difficulty to cut. Flint or granite aggregate is generally considered among the most difficult to cut.

The size of the aggregate can also play a factor in the cutting performance of a diamond blade. Concrete aggregates are often in the range of ½ to 2 inches. Concrete made with 2-inch flint aggregate will be extremely difficult to cut, but concrete with ½-inch flint aggregate may be cut more easily.

In addition to the aggregate, the type of sand used to make the concrete can influence the selection of a diamond blade. Many natural sands are quartzitic and have been rolled by water for many years and are smooth and dull. Conversely, manufactured sand usually contains sharp, abrasive edges that can wear a bond quite quickly.

Cutting concrete made with hard aggregates also requires more power. If there is not enough power, bit speed or blade speed should be reduced.

Blades used to cut hard aggregates should have segments with tough diamonds and a soft metal bond matrix, otherwise the diamond particles will wear even with the bond surface and the blade glazes over and is unable to cut. Likewise, segments for cutting soft aggregates should have hard metal bonds, so that the diamond particles are not lost before their cutting life is used up.

Green concrete can be very abrasive and require special protection for the steel core even though it is relatively soft material. The abrasive nature of green concrete can easily wear away the core just under the attachment point for the segment to the core. Manufacturers can supply blades with undercut protection positioned around the core to help slow the steel core wear.

Reinforcing Steel It is inevitable that anyone who is involved in cutting concrete will cut into steel reinforcement. It costs more to cut concrete with reinforcing steel because blade life will suffer and the cutting production will slow. Blade life can easily be reduced by 50 percent or more depending on the steel cross-sectional area in the concrete.

When a blade encounters steel it is often accompanied by sparks, which is a sure sign that steel reinforcement has been "discovered." The operator should reduce the speed of the blade and decrease water flow. Sometimes using interrupted pressure will aid in speeding up the cutting.

Troubles In the early days of concrete cutting, many operators learned that if the blade glazed over, they should turn the blade over so that the diamonds would face the concrete in the opposite direction thus exposing new sharp points. If the reason for the polishing or glazing has not been corrected, after one layer of diamonds have been popped out, the blade will once again slow and polish. This can cause waste and blade costs can easily increase by 10% or more. The same can happen when the operator hammers the segments to expose new diamonds. Today's diamonds are more likely to embed, not fracture, into the bond and increase the smooth bearing surface of the blade.

Troubleshooting Some of the more common problems encountered in the field and remedies are:

Loss of Tension Diamond blades are tensioned by the manufacturer. The blade is actually manufactured in the form of a dish that will straighten when the blade is rotated at optimum speed - the recommended rpm stamped on the blade. The loss of tension in a diamond blade can be caused for many reasons. The blade core could have become overheated from a lack of sufficient water being applied to the blade or a lack of side clearance that results from uneven segment wear. One should make sure the water supply is adequate and is reaching the core near the collars and sheeting out to the cutting area. A blade with more side clearance, and suited to the cutting application, should be used by the operator.

Blade tension may also be lost when a blade is misaligned on the saw, the blade flanges are not of the proper size, or the blade is not properly mounted on the arbor shoulder, causing the blade to bend when the flanges are tightened. The operator should make certain that the flanges are clean and of the proper size and are properly mounted and secured.

Segment Loss Overheating of the blade can cause segment loss. This is often the result of a lack of proper water being applied to the cutting area. Another reason for segment loss may be that the blade specification is too hard for the concrete being cut, causing the blade to become dull. In this instance, an operator should recognize that the material being cut is different than originally believed and a blade with a softer bond might be better suited to the new material. Segment loss can also occur when the blade is subjected to sharp sudden movements while in the cut or upon initial contact with the concrete. The operator should make slow and even contact between the blade and the material to be cut.

Core Cracking If the operator observes that the core is cracking, the blade specification being used may be too hard for the concrete or other material being cut. The operator should not put excessive pressure on the blade by pushing, jamming, or twisting the blade into the cut. All of these actions can put undue stress on the blade and can cause metal fatigue.

Blade Will Not Cut A blade that will not cut can be the result of a number of factors. The first is that the blade specification may not be the proper one for the material being cut. The operator should examine the segments on the diamond blade under magnification to find out why the blade is not cutting. If the operator finds that the surface of the segment is smooth and that the diamonds are not protruding, then the diamonds may be too friable, the bond too hard, or the speed of the blade may be too high. On the other hand if the operator finds that the diamonds are protruding too far from the bond with little bond support, the bond is not resistant enough for the abrasive material being cut, or possibly the diamond/bond combination is not right for the application.

If the operator examines the segment surface and finds that many of the diamonds are missing (popouts), then it is safe to assume that the diamond impact resistance is not sufficient or the combination of the diamond/bond is not right for the cutting application. The operator may find the diamonds in place but with an abnormally high amount of fractures or crushed crystals. The blade may cut fast initially but overall life is short because the diamonds are too friable or the blade has been subjected to excessive pounding.

The blade may cut well initially but then slows and eventually stops. The operator may find that the diamonds are in place, but are smooth or have flat tops and are still protruding above the bond surface. In this case the diamond may be too impact resistant, too large, too high a concentration, or the diamonds may just not have been pushed to their design operating condition.

Field Performance Once the blade is in the field, the cutting operator must use the appropriate blade for the job for best efficiency. When operating a diamond blade, an operator should regularly inspect for lost segments, uneven segment wear, developing cracks in the segment or steel core, undercutting, overheating, proper diamond exposure, loss of tension or arbor hole/drive pin distortion.

The operator should also regularly check common equipment maintenance points such as:

- Blade flanges
- Blade shaft bearings
- Tension of the drive belts
- Alignment of the axle and wheel bearings
- Water delivery system

Many variables can affect diamond blade performance and a knowledgeable operator will utilize his or her skills to optimize diamond blade performance. Diamond "wear" is a good and necessary characteristic for optimum performance of a diamond blade in a construction application.

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