Noritake Proposal

Featured Products and Technology

02

Vitrified-bond CBN Wheels for Internal Grinding with Increased Cutting Ability and Longer Life

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We have developed the "I-Queen," a vitrified-bond CBN wheel that's highly effective for internal grinding. This new bond with its excellent grain holding power and homogeneous structure achieve both an exceptional cutting ability and wheel life.

Long Life Vitrified-bond CBN Wheel for Internal Grinding

I-Queen

[Scope of application and expected benefits]

Metallic material		Non-metallic material		Other
Ferrous material	Non-ferrous material (Al, etc.)	Inorganic material (glass, ceramics)	Organic material (rubber, plastic)	Advanced material
●				

Shorter cycle time	Improved tool life	Improved machining quality	Improved workability	Environmental consideration
●	●	●		

Characteristics and Challenges of Internal Grinding

In recent years, the demand for bearings and ball screws for automobiles and industrial equipment has been increasing, and thus, the demand for grinding wheels (henceforth referred to as wheels) to improve the manufacturing of these bearings and ball screws. Internal grinding is particularly critical for ensuring the quality of bearings and ball screws. Noritake is developing internal grinding wheels that can be machined with high precision while maintaining both grinding efficiency and wheel life, in order to meet the requirements of the marketplace.

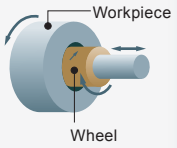
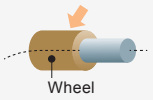
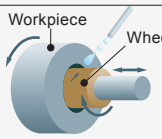
	Characteristics of internal grinding	Image diagram
1	The wheel diameter is small and susceptible to dimensional changes due to wear, etc.	
2	Low shaft stiffness makes it flexible and difficult to stabilize for accurate machining	
3	Clogging and loading are likely to occur because the gap between the workpiece and the wheel is small and thus it is difficult to supply coolant.	
4	Since the arc of contact between the wheel and the workpiece is substantial, grinding burn or the like is likely to occur.	

Fig. 1 Characteristics of internal grinding

Internal grinding has four characteristics (Fig. 1). The first is that the wheel diameter is small to grind the inside of the workpiece and is susceptible to dimensional changes due to wear, etc. Second, since the axial stiffness of the quill is low, it is too flexible and the workpiece accuracy is difficult to stabilize. Third, the gap between the workpiece and the wheels is small and thus, it is difficult to supply coolant, so clogging and loading are likely to occur. Fourth, the long contact arc between the wheels and the workpiece makes it easier to generate grinding burn, etc.

To combat the above mentioned features and problems, these wheels must have, "good cutting ability and long life". However, it is not easy to combine these two qualities. Wheels with good cutting ability tend to have a short life span, which raises concerns about (1) higher processing costs and (2) lower productivity. Particularly in internal grinding, the frequency of wheel replacement due to its short dressing interval and wheel life can be a challenge for productivity improvement. Usually, when attempting to extend wheel life, it is common practice to increase the wheel's grade and/or concentration. However, there have been cases in which it is difficult for traditional wheels to cope with problems such as, a shortage of cutting ability when the life is emphasized (Fig. 2).

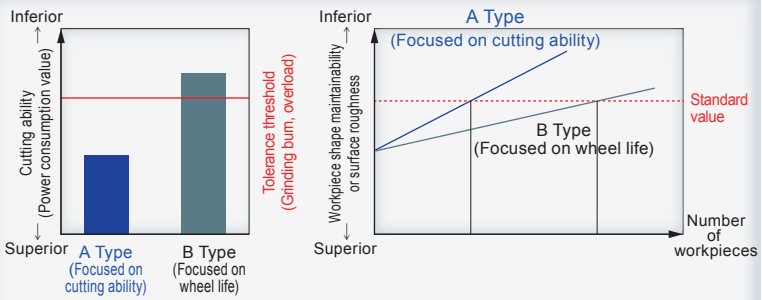


Fig. 2 Relationship between cutting ability and wheel life

In order to overcome this problem, we have developed the I-Queen, a wheel that can achieve both high cutting ability and a long wheel life.

I-Queen's Core Technologies (1) ~ Homogeneous Structure ~

Since a wheel used for internal grinding has a smaller diameter, and therefore, a smaller amount of working abrasive grains, creating variations in the structure is considered to have the greatest affect on wheel performance. As shown in Fig. 3 (a), when grinding is performed with a wheel of which the grains and bond are unevenly distributed and the gaps between grains are nonuniform, it is well known that problems such as clogging, loading, and breaking down are more likely to occur than when grinding is performed with a wheel having a homogeneous structure as shown in Fig. 3 (b). Noritake aims to maintain cutting ability and extend dressing intervals and thus, the overall life of the wheel, by using a homogeneous structure with improved grain distribution. For the I-Queen, we also developed technologies to improve the homogeneity of grain gap.

Fig. 4 shows the results of evaluating the distribution of grains. In the cross-sectional image of the wheel, the white areas are CBN grains, and the uniformity of distribution was evaluated from the standard deviation of the density and distribution of grains from the image taken of the wheel's surface. I-Queen has 25% better distribution of grain than traditional wheel. Improvements in the distribution of the grains, allows for an equal exertion of load on the grains during grinding, leading to reduced grinding force and reduced wheel wear.

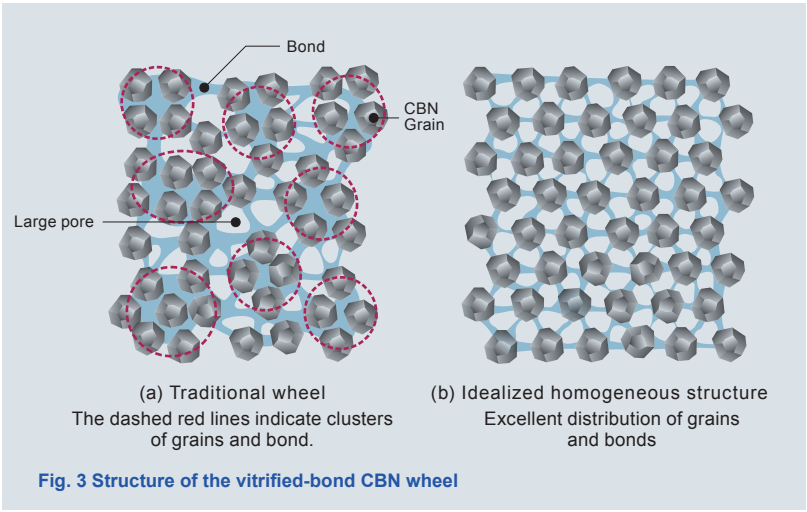


Fig. 3 Structure of the vitrified-bond CBN wheel

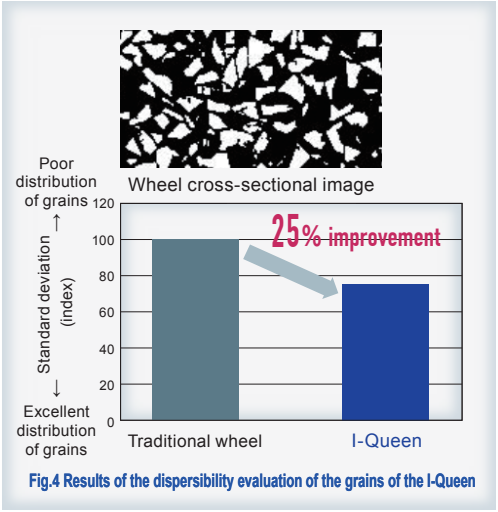


Fig.4 Results of the dispersibility evaluation of the grains of the I-Queen

I-Queen's Core Technologies (2) New Bond VQ1

When working to create wheels with high cutting ability and long wheel life, Noritake focused heavily on the bond. While it is the grain that does the actual grinding of the workpiece, the bond's ability to hold the grain also greatly affects the cutting ability and the wheel life.

As previously mentioned, when attempting to lengthen the wheel life of traditional wheels, it is typical to adjust the grade of the wheel, but this in turn increases the power consumption value, and thus lowers the wheel's cutting ability.

In order to solve this problem, we knew that we needed to develop a bond that would not reduce cutting ability if the grade was adjusted, and if the grade was left alone, would still have an increased wheel life. Our new bond, VQ1, developed based on this need, has an approximately 25% higher wheel strength and superior grain holding power than traditional wheels (Fig. 5). Higher bond strengths reduce the breaking down of grain, prolonging dressing intervals and reducing wheel wear. The same grain holding force as traditional wheels can be achieved with a smaller volume of bond and therefore, the reduction of grinding resistance can be expected (Fig. 6).

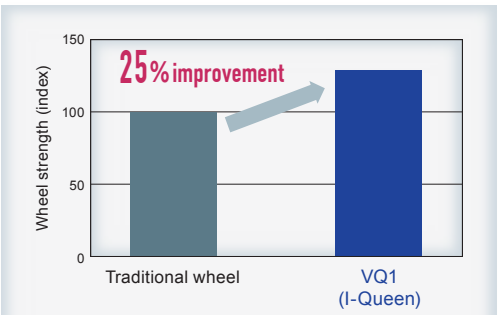


Fig. 5 Wheel strength

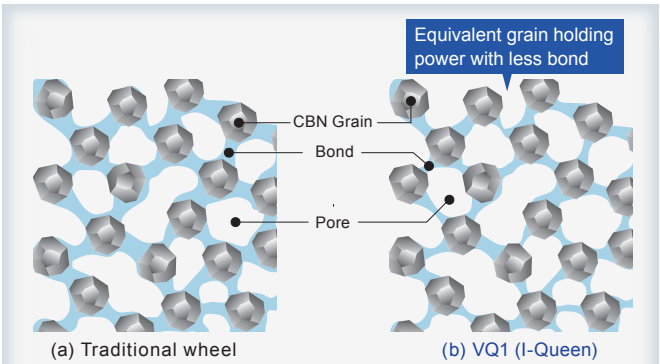


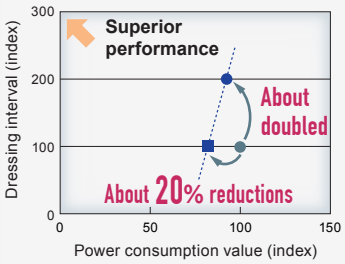
Fig. 6 Wheels structure

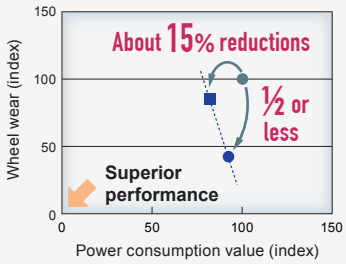
The I-Queen's Capabilities

In order to evaluate the performance of the I-Queen, a grinding test was conducted, comparing it with traditional wheels (Table 1 and Fig. 7). Cutting ability was evaluated by monitoring the power consumption value; and wheel life was determined by wheel wear as well as dressing intervals, which is determined by surface roughness. As a result, compared to traditional wheels of the same grade, the I-Queen (●) was less than or equal in power consumption value, and the dressing interval was doubled. Excellent cutting ability persists and the increases in grinding resistance and surface roughness deterioration are reduced, thereby increasing dressing intervals. In addition, because of the high bonding strength, the breaking down of grain is low, and the wheel wear is reduced by half or more, which can be expected to improve even in applications where shape retention is required. The surface condition of a traditional wheel and the I-Queen after grinding was measured (Fig. 8). The concavities and convexities of the wheel surface are shown in color. The red areas represent the convexities i.e., the grain cutting edge. Compared with traditional wheels, the I-Queen has a larger number of cutting edges remaining after grinding, and the cutting edges are well dispersed. From the

Grinding method	Internal grinding (wet)
Workpiece material	SUJ2(JIS)/52100(AISI)/100Cr6(DIN) hardened (φ28 × T12mm)
Wheel specification	CB230-VQ1 (I-Queen)
Wheel dimensions	φ25mm
Wheel peripheral speed	60 m/s

Table 1 Test conditions





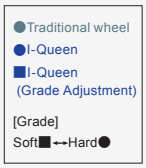


Fig.7 Test results

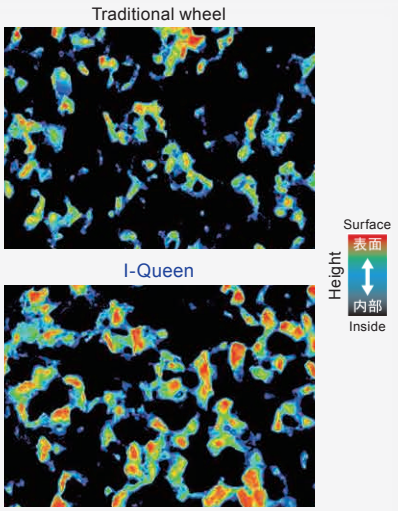


Fig. 8 Wheel surface state after continuous machining

above results, it can be concluded that the I-Queen is a wheel which achieves both exceptional cutting ability and wheel life due to the homogeneity of the wheel's structure and the characteristics of the new bond, VQ1; and therefor reduces the tool cost and improves productivity.

In addition, the grade adjusted I-Queen (■) reduced wheel wear by about 15% and power consumption value by about 20% at dressing intervals equivalent to those of traditional wheel. Since the I-Queen performance line exhibits more "good cutting ability and longer life" than traditional wheel, the I-Queen may be applied to higher efficiency or more endurance-focused applications by properly adjusting the wheel's specifications.

I-Queen in Markets

I-Queen has been well evaluated in a variety of internal grinding. Particularly in the bearing field, we have achieved a life extension of approximately 1.5 to 2.0 times that of traditional wheels, and we have received a favorable reputation for the advantageous shortening of dressing time and wheel-change time, as well as the reduction of processing costs. The reduction of downtime due to dressing has led to an improvement in the grinding efficiency of the entire manufacturing process.

Even if the traditional wheel dressing interval and levels of wheel wear are adequate for performance, adjusting the grade of the I-Queen can still greatly reduce grinding resistance. By selecting appropriate specifications, it is possible to increase the cutting speed without sacrificing workpiece accuracy, and it is expected to improve the efficiency of grinding by shortening the cycle time. We are continuing to develop such I-Queen features so that they may be applied to grinding in various fields, such as in the production of injection valve components and ball screw grooving.

Noritake is and will continue to develop grinding wheels that meet grinding conditions and performance requirements, as well as developing and improving products that meet the needs of our customers.

[Notes]
* Generally, in Japanese, a grinding wheel composed of diamond or CBN grains is referred to using the English word "wheel" rather than a the native Japanese term for a grinding wheel, "toishi." This can cause confusion among Japanese engineers.

Q How is work piece accuracy affected?

A It can be ground with the same accuracy as a traditional wheel. Because of its superior shape retention, it can be expected to extend the dressing interval.

Q In what areas can I use it?

A Its use is not limited to one field. It is applicable to all types of internal grinding.

Q Is dressing affected?

A It also has excellent dressing properties. Initial power consumption after dressing is lower than traditional wheels.

Q Are there any restrictions on the type of coolant that can be used?

A Both water-soluble and oil based can be used.

Q & A