Surface Photograph of Electroplated Tool

Technology Course

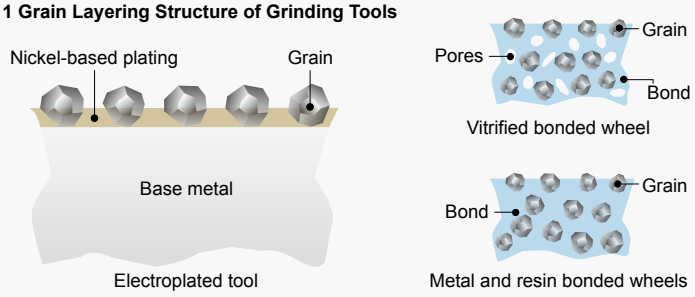
Electroplated Tools

For High Efficiency and High Precision Machining

Structure of Electroplated Tools

The electroplated tool is one of many products developed by Noritake with a unique structure and manufacturing method.
In electroplated tools, diamond or CBN grains are embedded and fixed with nickel plating onto surfaces of base metals (Fig. 1).

Fig. 1 Grain Layering Structure of Grinding Tools



The nickel plating which serves as the bonding media has higher grain holding strength than other grinding wheel bonds, which also allows excellent grain protrusion. Therefore even with a large cutting depth, grinding heat and chips are efficiently removed, and burning, clogging and loading are suppressed.

In addition, electroplated tools have some unique features which are not found in other grinding tools.

One is patterned electroplating, which improves cutting ability. Patterned electroplating further enhances the removal of ground chips by having a specific pattern on the electroplated surface. Due to its high chip removal capability, it can be used for dry grinding.

Due to the electroplating process, tools can be made with large, thin, or complex shapes, which are used in various fields for high efficiency and high accuracy grinding. Form grinding is superior in productivity and cost to conventional grinding. When grinding a workpiece with a complex shape such as a radius or step, conventional grinding wheels need to be dressed into specific shapes. The use of electroplated tools in form grinding is expanding due to the improvements in accuracy and technology of fixing grain onto the base metal.

The electroplated surface can be conditioned to control surface roughness and wear without reducing cutting ability.

Also, the base metal can be reused by removing the nickel plating and resurfacing, making it environmentally and economically friendly.

Next section explains the features of electroplated tools from the viewpoint of high efficiency and high accuracy.

Electroplated Tools for High Efficiency Grinding - Grain Protrusion

One of the advantages of electroplated tools is their use as a high efficiency grinding tool due to the large protrusion height of the grain. Other grinding tools require dressing to remove bond from around the grains and allow them to protrude. Because of the grain holding strength limitations of the bond, only about 30% of a grain's full diameter can protrude from the surface at maximum. For electroplated tools, even with standard specifications, more than 40% of the grain's diameter can protrude, allowing high efficiency grinding with a deeper cut (Fig. 2). Comparing the performance of resin diamond wheels and electroplated diamond tools, which are the most widely used types of diamond tools, we can confirm that electroplated diamond tools have higher cutting ability with lower power consumption value (Tables 1 and 3).

Fig. 2 Grain Protrusion of Electroplated Tool

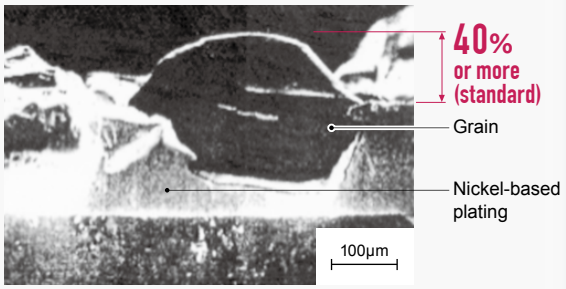
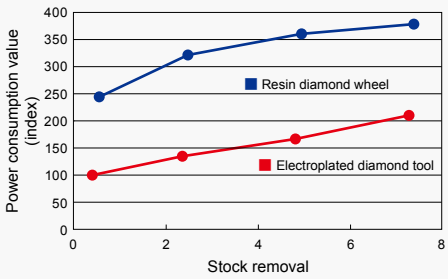


Table 1 Test Conditions

Grinding method	Wet surface grinding
Workpiece material	Carbide

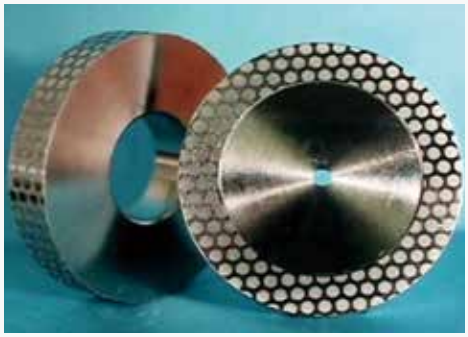
Fig. 3 Grinding Performance of Electroplated Diamond Tools and Resin Diamond Wheels



Electroplated Tools for High Efficiency Grinding - Patterned Electroplating

When loading occurs due to grinding burn or clogging with high efficiency grinding, one solution is to increase the grain size. However, larger grains will result in a rougher surface finish. If surface finish requirements prohibit the use of a larger grain, introducing a chip pocket (i.e. expanding the distance between grains) for effective chip removal and improved coolant supply is another effective option. Noritake uses patterned electroplating as shown in Fig. 4 to improve chip removal and coolant supply, thereby reducing clogging.

Fig. 4 Patterned Electroplating

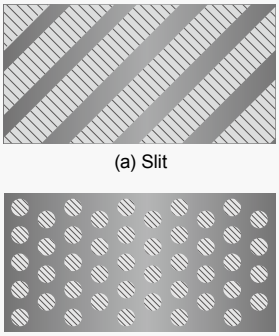


Patterned Electroplating

Available electroplating patterns include slit (Fig. 5 (a)) and polka-dot (Fig. 5 (b)) patterns.

The slit pattern is mainly used on the outer diameter of the tool to improve chip removal and coolant supply. The polka-dot pattern also improves chip removal and coolant supply, but it also reduces the number of grains in contact with the workpiece, and therefore also the grinding force. This pattern is often applied to the sides of the tool, or the face of cup-shaped tools. In one case of dry grinding of ceramic material with a wide grinding area, cutting ability was remarkably reduced due to heavy clogging. When the polka-dot pattern was applied, chip removal improved and 1.3 times the previous tool life was achieved (Fig. 6).

Fig. 5 Examples of Available Patterns

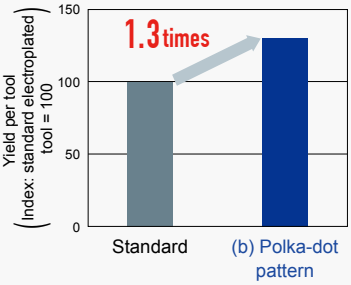


(a) Slit

(b) Polka-dot

*Hatched area: Electroplated area

Fig. 6 Comparison of Standard and Patterned (Polka-Dot) Electroplated Tools

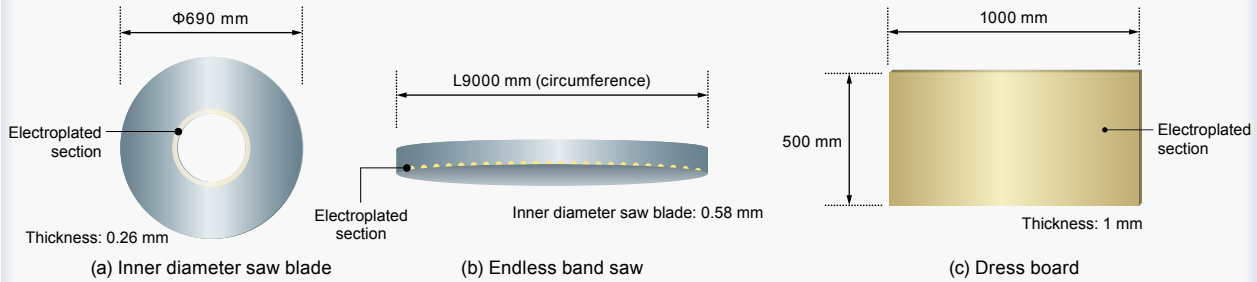


Electroplated Tools for High Precision Processing - Large, Thin Wheels

Since electroplating chemically fixes grains directly to the base metal, there is no risk of thermal or pressure-induced deformation in the manufacturing process, and high precision tools can be produced with large diameters of 1,000 mm or more, and thicknesses of 1 mm or less (Fig. 7).

Typically the larger the product and the larger the area where the grain layer is deposited, the greater the chance is that properties like grain layer thickness, number of grains, and the extent of grain protrusion will not be uniform depending on the accuracy of the plating. Noritake has developed technology which enables the production of large and thin tools with uniform grain layers. This ensures stable cutting ability and enables high efficiency and high precision grinding with large size thin tools.

Fig. 7 Example of Large, Thin Base Product



Cost Reduction and Increased Productivity through Electroplated Tools for High Precision Machining - Form Shapes*

Since electroplating adheres to the shape of the base metal, it's easier to create a form shape such as a radius than other grinding tools (Fig. 8).

The benefits of form shapes include improved processing efficiency and higher precision. Grinding of complicated shapes without a form shaped tool takes more processes and makes it difficult to achieve the required accuracy. Form shaped electroplated tools can be used efficiently on workpieces of complex shapes simply by determining the positioning of the electroplated tool and workpiece (Fig. 9, Table 2). In plunge grinding, the geometry of the electroplated tool is transferred onto the workpiece. Therefore, if a high precision electroplated tool is used, the workpiece accuracy can be easily achieved.

Fig. 8 Form Shape Tool Manufacturing Method

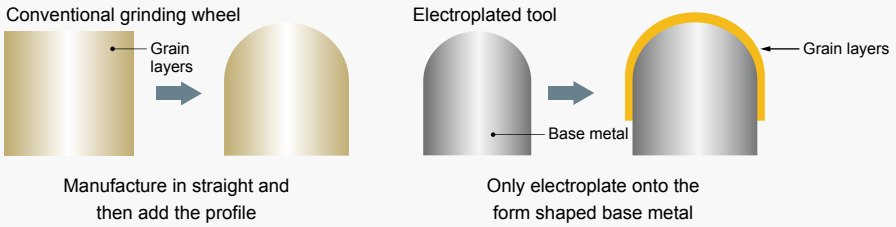


Fig.9 Form Grinding with Electroplated Tools

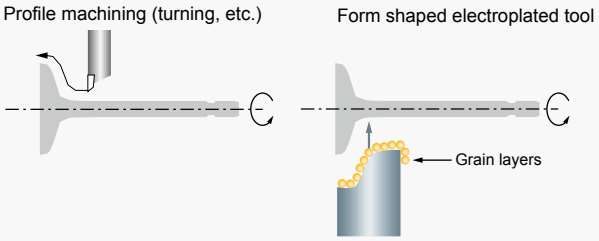


Table 2 Merits of Form Shaped Electroplated Tool

	Profile machining (turning)	Form shaped electroplated tool
Tool cost (index)	1	200
Tool life	20～30 min	1 month
Cost per unit (index)	1	1/7
Productivity (index)	1	1.6

Surface Roughness and Tool Wear Control - Abrasive Surface Conditioning

Like conventional and other Diamond/CBN wheels, the need to reduce tool wear and surface roughness is also present in electroplated wheels. One way to address these issues with electroplated tools is through surface conditioning techniques. This aligns the tips of the cutting edges, allowing a fine surface roughness without significantly reducing the cutting ability (Fig. 10).

Fig. 10 Grinding Performance

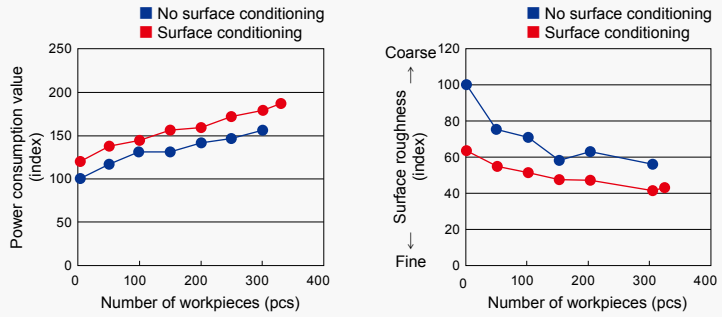


Table 2 Test Conditions

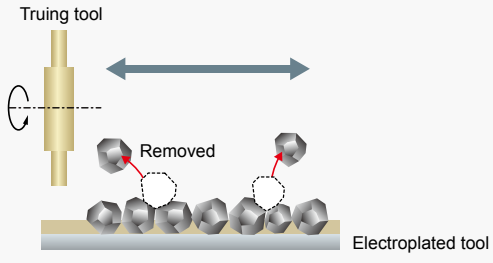
Grinding method	Cylindrical grinding
Workpiece material	SCM435 (JIS) / 4B5 (AISI) / 34CrMo4 (DIN) φ60×T5 mm (hardened HRC48)
Grinding efficiency	10 $mm^3/mm \cdot s$

Technology Aimed at Higher Accuracy - Truing

The accuracy of the electroplated tool is determined by the geometrical accuracy of the base metal onto which the grains are fixed, and by the accuracy of the electroplating process. Conventional grinding wheels require truing prior to usage to correct surface run-out, and also occational dressing is required to remove the surface as it wears to maintain the performance. Noritake electroplated tools are made with great accuracy. A high precision machined base material and a uniform abrasive layer are the two major contributing factors. This eliminates the necessity of truing throughout tool life.

In cases requiring very high accuracy, even electroplated tools can be trued. As shown in Fig. 11, truing is the process of crushing dull cutting edge on the surfaces of the grains to improve geometric accuracy. This can damage the grain and affect the performance of the product, especially the tool life. For this reason, Noritake is developing truing methods that minimize damage to the grain and improving the accuracy of the electroplating to eliminate the need for truing.

Fig. 11 Truing



[Notes]

* Form Shape: Intended profile. The application in which a form shape grinding wheel is used for plunge grinding referred to as form grinding.

Q Can any base material be used for the core?

A Anything that conducts electricity can be used. However for materials with an oxidized layer such as stainless steel or aluminum, a special surface treatment is required before electroplating can take place. Even with non-metal materials, it is possible to treat the surface to enable conductivity so that it can be electroplated.

Q&A

[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
●				

[Author] Toshiaki Sawamura
Industrial Products Group,
Engineering Division,
Product development division
Electroplated group