



[Author] Tomomi Ohashi
Grinding R&D Section,
Grinding & Finishing Technology Development Department,
Engineering Division, Industrial Products Group

Vitrified Ceramic Grinding Wheels with Improved Performance on Hard Chrome Plating



Hard chrome plating is classified as difficult-to-cut because of its high hardness. Grinding wheels tend to have lower cutting ability and wheel life when grinding these materials compared to common metals. To achieve better performance on hard chrome plating, we recommend Noritake "CXE" ceramic wheels.

High Performance Vitrified Ceramic Grinding Wheels for Maintaining Excellent Cutting Ability.

CXE Grinding Wheels

[Scope of Application and Expected Benefits]

Metallic materials		Non-metallic materials		Other
Ferrous materials	Non-ferrous materials (Al/Cu, etc.)	Inorganic materials (glass and ceramic)	Organic materials (rubber, plastic)	Advanced materials
●				
Shorter cycle time	Improved tool life	Improved machining quality	Improved workability	Environmentally friendly
●	●		●	



What is Difficult-to-Cut Chrome Plating?

In grinding, there are various materials described as difficult-to-cut materials. Chrome plating is generally divided into decorative chrome plating and hard chrome plating (industrial purpose chrome plating). In the field of grinding, the latter one is classified as a difficult-to-cut material (in this article, we will refer to Hard Chrome plating as simply "chrome plating").

The main characteristic of chrome plating is its very high hardness, which is why it is called a difficult-to-cut material. The hardness of chrome plating depends on the plating method, but its Vickers hardness ranges from Hv750 to Hv1100, which is hard compared to other common metals ^[1] (Fig. 1).

Another important feature of chrome plated materials is their low coefficient of friction. The surface of chrome-plated material is covered with a coating of dense chromium trivalent oxide (Cr_2O_3).

Since this metal chromium surface slides when in contact with other materials, the Cr_2O_3 on the surface will wear slightly, and the wear powder will work as a lubricant ^{[2][3]}.

Due to the characteristics described above, chrome-plated materials are used in industrial components in various fields. With rolling-mill rolls, for example, by applying chrome plating to the surface of the roll, surface wear can be prevented. Chrome plating is applied to moving parts that rub up against each other like shafts, piston rods, and bearings to improve wear resistance and lower friction (Fig. 2).

Fig. 1 Hardness Comparison of Chrome Plating and Other Metals

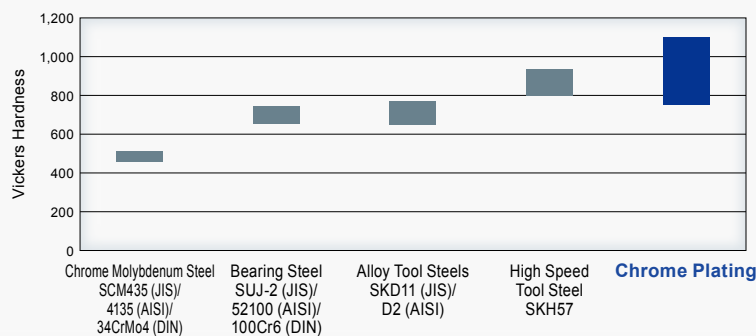
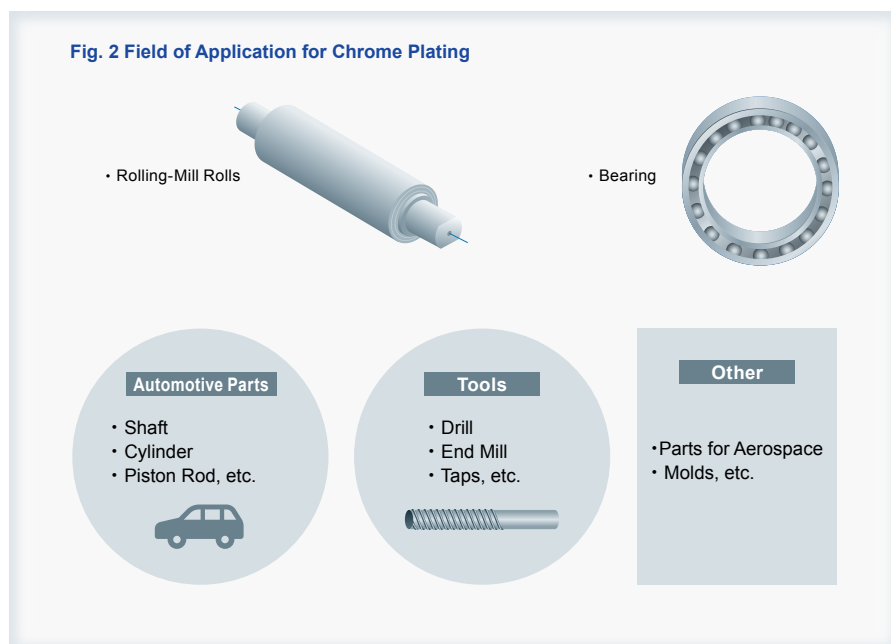


Fig. 2 Field of Application for Chrome Plating



Issues with Grinding Chrome Plating

So, just how hard is it to grind chrome plating? To investigate this, we conducted a cylindrical grinding trial to compare a grinding wheel's performance on chrome plating to its performance on chrome molybdenum steel (SCM435) (Table 1). The grinding wheel used was a Noritake ceramic "CX" wheel. Because the CX ceramic grain has a fine crystalline structure, is tougher and has higher cutting edge retention than other conventional grains, it is capable of high-efficiency and high-precision grinding [4].

When the chrome-plating was ground, power consumption was about 2.4 times higher and wheel wear was about 2.1 times higher than that of SCM435 (Fig. 3). This is because the hardness of the chrome plating makes it difficult for the grain to bite into the workpiece, causing the grains to dull more quickly and dramatically reduces grinding performance. Also, the surface roughness of the chrome-plated workpieces tended to be finer after grinding than that of the chrome molybdenum steel.

If we observe the wheel surface after grinding each material, many shiny white areas appear on the wheel after

Table 1 Test Conditions (Chrome-Plated Material Differences)

[Grinding wheel]	
Dimensions	φ405 × T25 × φ127 mm
Specifications	CX80-V (CX grinding wheel)
[Workpiece]	
Material, Hardness	Chromium plating (base metal S45C) Approx. Hv850
	Chrome molybdenum steel (SCM435) HRC48 (Hv484 equivalent)
[Dressing conditions]	
Dresser	0.8LL Single-point dresser
Dressing lead	0.1 mm/r.o.w.
Cutting depth	φ20 μm/Pass (cut at both ends)
[Grinding conditions]	
Grinding method	Cylindrical grinding
Grinding wheel speed	45 m/s
Workpiece peripheral speed	0.45 m/s
Grinding efficiency*	5.0 mm ² /mm·s
Spark out	10 rev
Coolant	Water-based coolant

Fig. 3 Test Results (Chrome Plating Comparison)

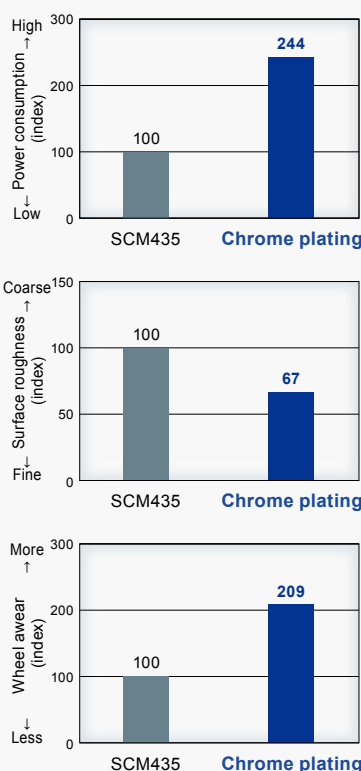
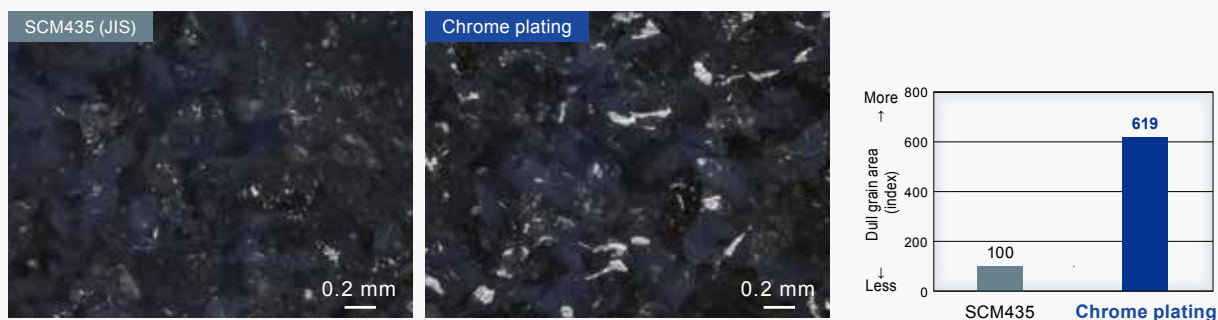


Fig. 4 Wheel Surface Condition and Dull Grain Area After Grinding



grinding the chrome plating which indicates dull cutting edges on the grains (Fig.4). The surface area of these shiny, dull spots is about 6.2 times greater after grinding the chrome plating than it is after grinding SCM435. Power consumption for grinding the chrome plating is shown to be more than double the value for the SCM435, which makes sense considering the significant difference in dulled grains, and the greater surface area in contact with the workpiece.

These results show how the high hardness of chrome plating reduces a grinding wheel's cutting ability and wheel life.

CXE Grinding Wheel Capability

We evaluated the grinding performance of a vitrified-bonded grinding wheel using conventional abrasive grains (WA, SA*) and ceramic grain (CX, CXE) in order to confirm the optimal grinding wheel specifications for chrome plating (difficult-to-cut materials) (Table 2, Fig. 5).

Using the WA wheel as a standard, we first compare the results of the SA wheel. The SA wheel's results are very close to those of the WA wheel for power consumption, surface roughness, and wheel wear. However, conventional abrasive grains lack the toughness needed to effectively grind chrome plating. The excessive wear on these grains makes it so there is no significant difference in grinding performance.

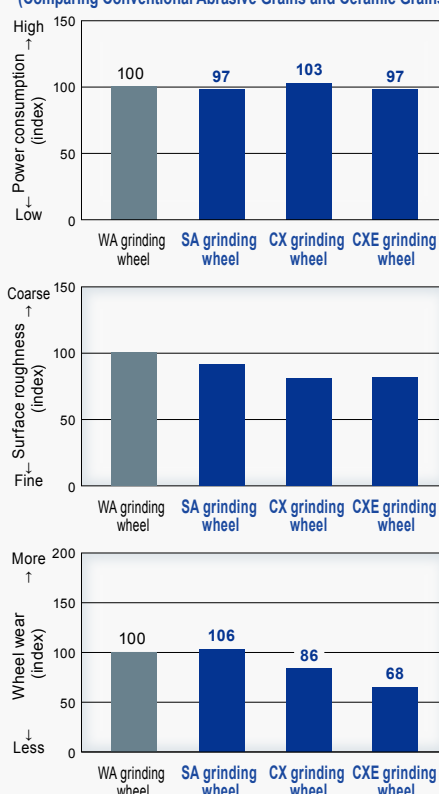
Next, let's look at the grinding performance of the CX wheel. Compared to the WA wheel, it shows almost the same power consumption, but produces a smoother surface finish and reduces wheel wear by over 10%. Since CX grains are tougher than WA grains, they can suppress excessive wear and surface roughness even when grinding hard materials like chrome plating. Because of this we can say that the CX wheel's performance is superior to that of the WA wheel.

Now that we have established the superiority of CX wheels in grinding chrome plating, we will compare it to our new CXE ceramic grain. Even among ceramic grains, the CXE grain is the sharpest and has superior wear resistance, so it

Table 2 Test Conditions
(Comparing Conventional Abrasive Grains and Ceramic Grains)

[Grinding wheel]	
Dimensions	φ405 × T25 × φ127 mm
Specifications	CX80-V (CX grinding wheel)
	CXE80-V (CXE grinding wheel)
	WA80-V (WA grinding wheel)
	SA80-V (SA grinding wheel)
[Dressing conditions]	
Dresser	0.8LL Single-point dresser
Dressing lead	0.1mm/r. o. w.
Cutting depth	φ20 μm/Pass (cut at both ends)
[Grinding conditions]	
Grinding method	Cylindrical grinding
Workpiece material hardness	Chrome plating (base metal S45C)
Grinding wheel speed	Approx. Hv850
Workpiece peripheral speed	0.45 m/s
Grinding efficiency*	5.0 mm ³ /mm ² ·s
Spark out	10rev
Coolant	Water-based coolant

Fig. 5 Test Results
(Comparing Conventional Abrasive Grains and Ceramic Grains)

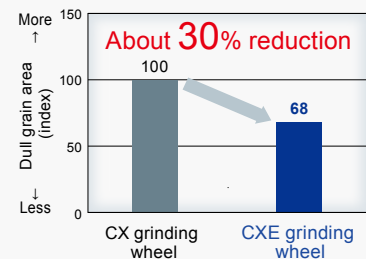
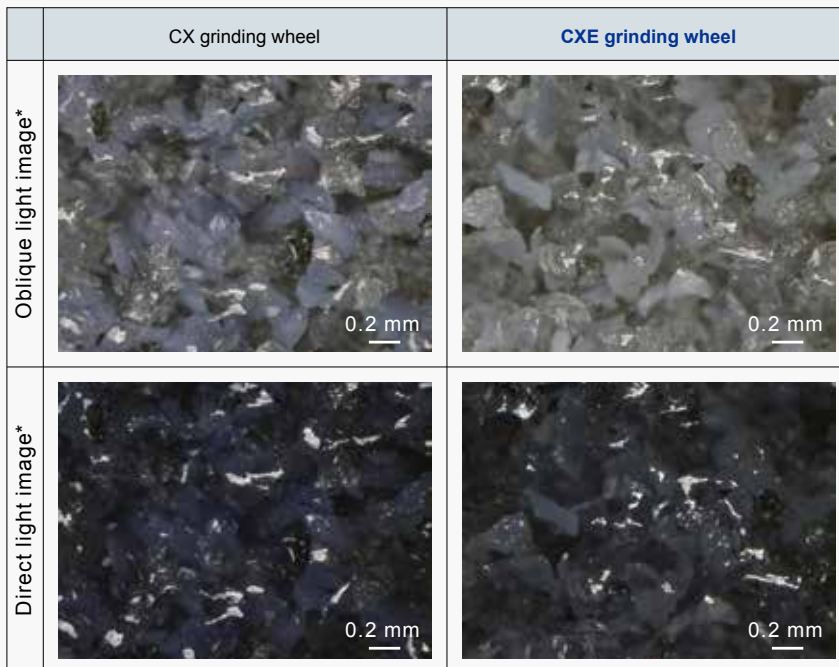


maintains its sharp cutting edges longer and can bite into the workpiece more easily. In addition, CXE grinding wheels use a dedicated bond type (V500) to bring out the full potential of the grain, resulting in improved grinding efficiency and grinding ratio [5].

Looking at the grinding performance of the CXE wheel, you can see that wheel wear is reduced further than that of the CX grinding wheel. Compared with the WA wheel, the CXE wheel has about 30% less wheel wear and is the best among the four types of grinding wheels.

In Fig. 6 we can observe the grinding wheel surfaces of the CX and CXE wheels after grinding. Oblique light images show that there is not much difference between the CX wheel and the CXE wheel in terms of breakdown of the grains and clogging caused by grinding chips, but there is a difference in the dull areas of the grains, indicated by the shiny spots in the images. In the direct light images, the CXE wheel has less dull cutting edges and each of these areas are smaller compared to the CX wheel. This is evidence that the CXE wheel can maintain its cutting edge longer, reducing wheel wear.

Fig. 6 Wheel Surface Condition and Dull Grain Wear After Grinding (Comparing CX and CXE Grinding Wheels)



[Notes]

- * CX Grain: One of the ceramic grains among conventional abrasive grains mainly composed of aluminum oxide (Al_2O_3). CX grain has sharp shape and excellent cutting edge maintainability.
- * SA Grain: One of the monocrystalline fused conventional abrasive grains mainly composed of alumina (Al_2O_3).
- * Grinding Efficiency: The volume of stock removal per unit time.
- * Grinding Ratio: Calculated as [stock removal/wheel wear].
- * Oblique Light Image: A method of photographing the grinding wheel surface to emphasize unevenness by applying light onto the surface obliquely. This method is mainly used to observe the appearance and wear condition of a grinding wheel.
- * Direct Light Image: A method of photographing the grinding wheel surface that applies light perpendicularly onto the surface. This method is mainly used to observe dull areas on grains.

[References]

- [1] Nobuo Suzuki: Iron and Steel Materials Handbook, Maruzen Corporation (1992)
- [2] Ryokichi Shimpo: Characteristics of Hard Chromium Plating, Surface Techniques, 65, 3, (2014)123-128
- [3] Kishi Matsudaira: Chromium Plating, Nikkan Kogyo Shimbun (1964)
- [4] Motoya Mizutani: Grinding Wheel Overview, Tribologist, 63, 3, (2018) 135
- [5] Hideto Kawamoto: CXE-Series, NORITAKE TECHNICAL JOURNAL 2018, (2017)36-39

Q How does one choose between CX and CXE wheels?

A The CXE grinding wheel can be expected to improve cutting ability and life over the CX wheel, and is especially recommended for grinding applications which require high grinding efficiency.

Q Is the CXE grinding wheel also a valid option for plating materials and thermal spraying materials other than chrome?

A The optimal grain type will vary depending on plating or spray material. For details, please do not hesitate to contact Noritake.

Q & A