

“GRANMET®” Cutting Tool Materials and “MightyShield®” Coating Realize High-speed Gear Processing



As one of the few manufacturers that handle both tools and machines for cutting gears, Mitsubishi Heavy Industries Machine Tool Co., Ltd. is the first company in the world to make complete dry cutting of gears using a high-speed steel hob^{*1)} and a pinion cutter^{*2)} possible. This both shortens machining time and extends tool life dramatically. As a result, high-speed dry gear cutting at 200 m/min or faster has become widespread at gear mass-production sites, and mass-production cutting in the high-speed region exceeding 250 m/min has also commenced recently.

This paper presents our GRANMET^{®*3)} cutting tool material and MightyShield^{®*3)} coating that enable high-speed gear cutting at low cost.

*1) Hob: Cylindrical cutting tool used mainly for cutting external gears

*2) Pinion cutter: Disk-shaped cutting tool used mainly for cutting internal gears.

*3) “GRANMET” and “MightyShield” are registered trademarks of Mitsubishi Heavy Industries Machine Tool Co., Ltd.

1. Features of GRANMET®

One of the features of GRANMET[®] is its high hardness in high temperature environments. In high-speed cutting of gears, the cutting heat generated by the friction between chips and the tool causes a rapid temperature increase at the tool tip, as well as tool wear progress. Therefore, whether the tool material can maintain high hardness even in a high temperature environment is important. **Figure 1** shows the relationship between temperature and hardness. Compared with conventional high-speed steel, GRANMET[®] has less hardness degradation even in high temperature environments and is expected to be highly resistant to wear during high-speed cutting.

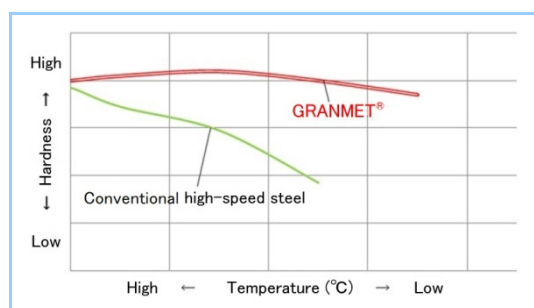


Figure 1 Relationship between temperature and hardness

The following introduces an example of hob cutting with a GRANMET[®] hob. Usually, the tool wear in hob cutting is classified into two types. One is flank wear that occurs on the tool flank due to the friction between the flank and the workpiece, and the other is crater wear that occurs on the tool rake surface due to the friction between the rake surface and chips. In high-speed cutting regions, crater wear tends to be dominant among the two types.

Dry hob cutting at a cutting speed of 300 m/min was performed. **Table 1** lists the cutting conditions at that time, and **Figure 2** shows the amount of tool wear. The GRANMET[®] hob

reduced the amount of crater wear by 50% compared with conventional high-speed steel hob at the cutting length of 60 m in 300 m/min high-speed dry hob cutting. When conventional high-speed steel is used, tool wear progresses rapidly in high-speed cutting, so there is a problem with the tool life. However, the use of GRANMET[®] can suppress the progress of tool wear and realize mass-production gear cutting at low cost and with high productivity.

Table 1 Cutting conditions

Workpiece specifications	Module	2.25
	Number of teeth	52
	Pressure angle	17.5°
	Helix angle	23°LH
Hob specifications	Outer diameter	φ 75
	Number of starts	3
	Number of gashes	16
Cutting conditions	Cutting speed	300m/min
	Axial feed	2.4mm/t.rev
	Cutting method	Dry cutting No shift cutting

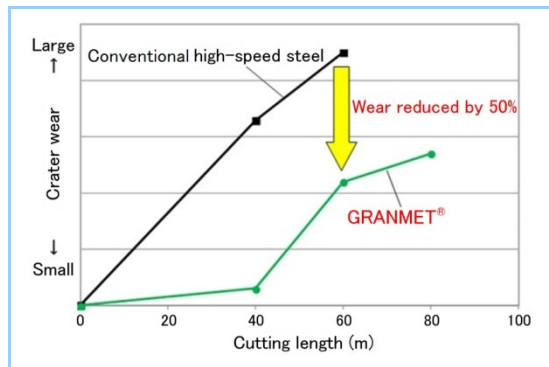


Figure 2 Relationship between cutting length and crater wear

2. Features of MightyShield[®]

The features of MightyShield[®] include its hardness, which is as extremely high as HV4000, as well as its high adhesion. **Figure 3** shows the hardness of our and competitors' coatings. MightyShield[®] has overwhelmingly higher hardness than other coatings. Generally, when the hardness difference between substrate and the coating is larger, the coating easily peels off during cutting. We developed an original technology capable of obtaining high adhesion to realize the practical use of a high wear-resistant coating with a hardness of HV4000 and succeeded in suppressing tool wear in cutting as a result.

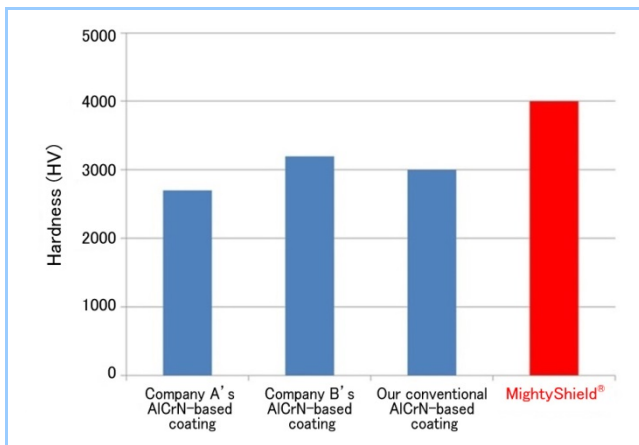


Figure 3 Hardness of various coatings

Another major feature of MightyShield[®] is that the amount of tooth profile change caused by recoating can be suppressed. High-speed hob cutting requires recoating for recovering a worn cutting edge. When this recoating is repeated and the tooth profile change of the hob accumulates, the precision of produced gears is affected. **Figure 4** illustrates the amount of tooth profile change caused by recoating. By using MightyShield[®], the amount of tooth profile change caused by recoating was suppressed to 30% compared with our conventional coating, and stable-precision gear cutting was made possible.

The following introduces an example of hob cutting using a hob coated with MightyShield[®]. **Table 2** lists the cutting conditions for this test, and **Figure 5** shows the amount of tool wear. In high-speed dry cutting at a cutting speed of 400 m/min, MightyShield[®] improved the tool life by about 1.5 times compared with our conventional coating.

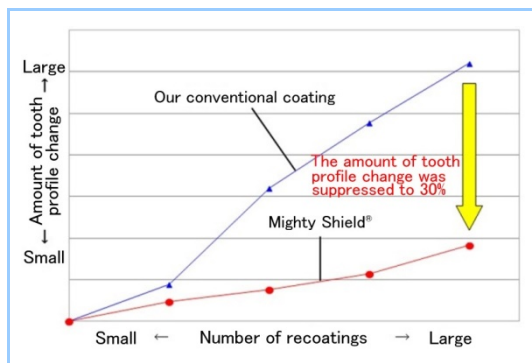


Figure 4 Amount of tooth profile change caused by recoating

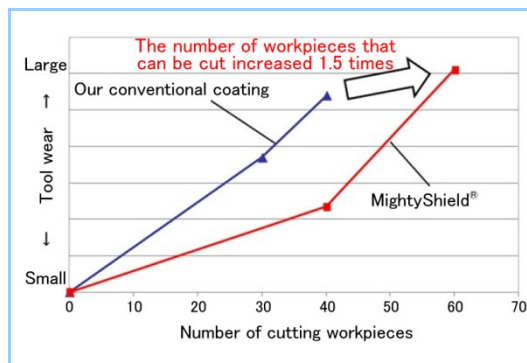


Figure 5 Relationship between number of cutting workpieces and tool wear

Table 2 Cutting conditions

Workpiece specifications	Module	2.25
	Number of teeth	46
	Pressure angle	17.5°
	Helix angle	23°LH
Hob specifications	Outer diameter	ϕ 75
	Number of starts	3
	Number of gashes	16
Cutting conditions	Cutting speed	400m/min
	Axial feed	1.7mm/t.rev
	Cutting method	Dry cutting No shift cutting

In recent years, high-speed cutting using water-soluble coolant has also been used, so the need for long-life tools that can be used for both high-speed dry cutting and high-speed water-soluble coolant cutting has been increasing. MightyShield[®] is highly wear-resistant not only when used for high-speed dry cutting, but also when used for high-speed water-soluble coolant cutting, and contributes to productivity improvement and cost reduction under various cutting environments.

3. Future prospects

We developed GRANMET[®], a tool material that can maintain high hardness even in a high temperature environment in high-speed cutting, and MightyShield[®], a versatile coating that is highly wear-resistant when used for either dry or wet cutting environments, and succeeded in dramatically extending the tool life.

We will continue to develop new next-generation materials and new coatings that realize even higher speeds and longer life. Taking advantage of our strength in being one of the few manufacturers in the world that handle both tools and machines for cutting gears, We will offer new gear cutting technologies.