Technical Change of Super Dry Coating for Gear Cutting with Low Cost and High Efficiency

Precision Cutting Tool &
Automobile Parts Sales Group
Sales Department, Machine Tool Division
Machinery, Equipment & Infrastructure

Mitsubishi Heavy Industries, Ltd. (MHI), deploying its diverse business operations, enjoys a high reputation at home and abroad as one of the few machine tool manufacturers that deals in both tools and machines for gear processing and as a unique manufacturer that provides total solutions relating to gear processing technology from gear cutting to gear grinding. In 1997, MHI enabled full-dry processing of gears for the first time in the world, using a hob [Note 1)] and pinion cutter [Note 2)] made of high-speed steel, and has since realized dramatic savings of processing time as well as extension of tool life. These achievements of MHI have allowed the widespread dry processing of gears in many of the production sites where gears are mass-produced and processed.

In this paper, the super dry coating process that enabled low-cost high-efficiency gear processing is introduced.

Note 1) Hob: A cylindrical cutting tool mainly used to machine external gears

Note 2) Pinion cutter: A disk-shaped cutting tool mainly used to machine internal gears

1. Advantages of dry cutting

Dry cutting is advantageous in that it uses no cutting fuel at all and so never causes soot during machining, thereby resulting in an improved work environment. In addition, gears can be cut at a higher speed than conventional wet cutting with oil, and the life of tools also increases dramatically, quite advantageously realizing low-cost, high-productivity gear cutting.

The realization of full-dry gear cutting was greatly contributed to by the development of a machine tool for dry cutting, as well as by the development of super dry coatings to protect tool edges from cutting heat. Dry machining by high-speed cutting causes the cutting heat generated by the friction between the chips and the tool to rapidly increase tool-edge temperature, thus promoting wear. The tool edge is covered by a highly heat and wear-resistant coating, which plays the role of blocking and protecting the tool edge from cutting heat. As far as dry machining by high-speed cutting is concerned, the coating performance greatly affects tool life.

Figure 1 exemplifies the dry cutting of gears with a super dry coating hob. Unlike a TiN coating hob typically used in conventional wet machining with a cutting fluid, dry machining at a cutting speed of 200m/min is possible, not only reducing the conventional gear cutting time in half, but also increasing the number of gears cut 6.6 fold, thus proving the dramatic improvement of tool life. Previous dry machining of gears with a TiN coating hob couldn't be used in mass production since the tool life became too short, while super dry coating enabled stable cutting in dry machining, thus realizing the mass production of low-cost, high-productivity gear machining.

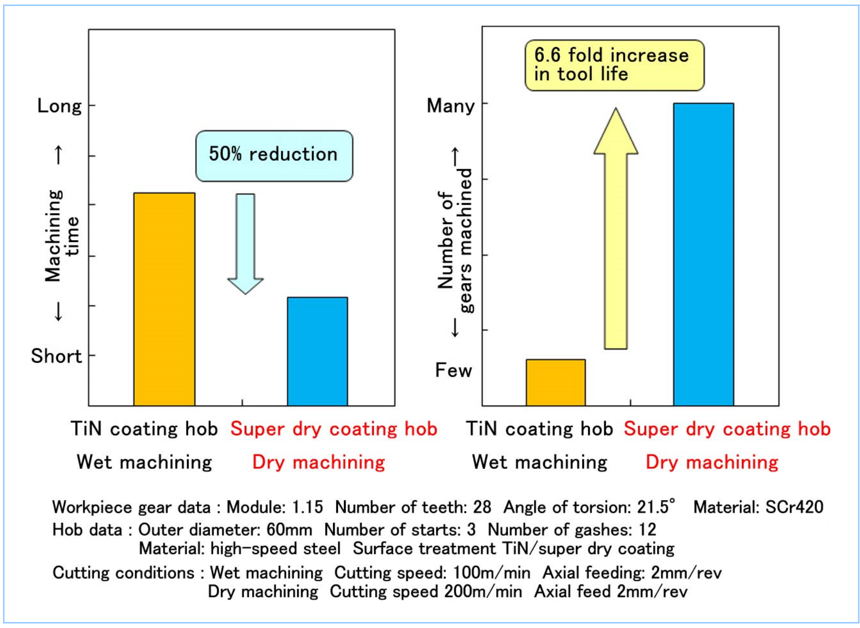

Figure 1 Example of dry gear machining with super dry coating hob

2. Features of super dry coating

The greatest feature of super dry coating lies in its characteristics of excellent oxidation resistance at high temperature. **Figure 2** shows the initial oxidation temperature measurements of the super dry coatings [Note 3)] so far developed. In high-speed, cutting-based dry machining, the sharp increase in tool edge temperature causes the coating surface to be rapidly oxidized, hence promoting wear, but the higher the temperature at which oxidation starts, the slower the progress of wear, thereby resulting in a longer tool life. In Figure 2, the initial oxidation temperatures of Super Dry III and Super Dry IV exceed 1300°C, proving their significantly high resistance to oxidation.

Note 3) State of super dry coating development: Super Dry I was first developed. Development and market introduction have already progressed to Super Dry II to IV.

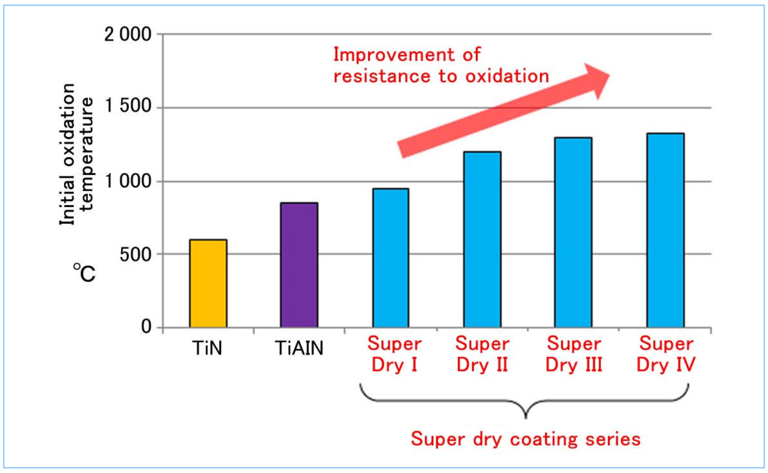

Figure 2 Initial oxidation temperature of super dry coating

Figure 3 shows the roughly estimated gear cutting speed of Super Dry I to IV applied to a high-speed steel hob. All of the super dry coating hobs are usable for dry machining, but the higher the coating's initial oxidation temperature, the higher the possible gear cutting speed. High-speed dry machining of gears with a hob made of cemented carbide was also utilized previously, but was not universally adopted because of an increase in the cost for tools, the hindrance of long-term stable machining due to tool edge breakage (chipping) caused by intermittent cutting and for other reasons. At present, the further improvement of super dry coatings has realized the stable machining of gears at a cemented-carbide hob-equivalent cutting speed of 300m/min, even using a hob made of high-speed steel.

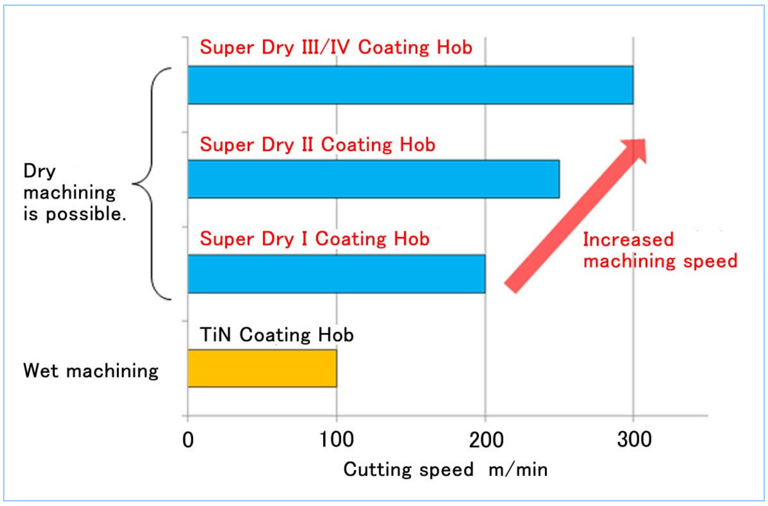

Figure 3 Roughly estimated speed of gear machining using each super dry coating hob
(Machining speed indication for 3 or less-module carburized material (of HB180 or less in hardness) as targeted workpiece gear)

3. Future outlook

MHI enabled full-dry processing of gears in 1997 for the first time anywhere in the world, using a hob and pinion cutter made of high-speed steel, and has since realized dramatic savings of processing time, as well as the extension of tool life. This has made low-cost, high-productivity machining for mass production possible.

MHI intends to continue to not only proceed with the development of mainly coating-purpose tools for the realization of further savings of processing time and the extension of tool life, but also to continually provide total solutions related to gear machining technologies, taking advantage of our strength as a developer/manufacturer of both tools and machinery, and satisfying many customers.