Advanced Dry-Cutting Gear Shaper SE25A and Super Dry II Coating

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1. Introduction

Dry cutting using high-speed hobbing, first commercialized by Mitsubishi Heavy Industries, Ltd. (MHI), uses no coolant, realizing a safe, clean working environment and dramatically improving productivity. MHI received the International Trade and Industries Minister's Award in fiscal 1998," the highest prize for energy-saving equipment.

MHI recently developed the Mitsubishi dry cutting gear shaper SE25A based on dry-cutting technology for the dry-hobbing machines. The sections that follow introduce the newly developed SE25A and Super Dry II Coating, a dry-cutting tool with resistance against oxidation and wear at high temperatures thus enabling better high-speed dry cutting.

2. Dry Cutting Gear Shaper SE25A

2.1 Specifications

Cutting internal and stepped gears is done by a gear shaper. A workpiece is cut by rotating the tool and the workpiece synchronously while stroking the tool in the direction of the gear lead.

The SE25A handles a maximum outer workpiece diameter of 250 mm and shapes transmission gears for automobiles and motor cycles, which have a high demand. **Table 1** lists the SE25A specifications.

Table 1 Specifications of Dry Cutting Gear Shaper SE25A

Maximum part diameter	(mm)	250	
Maximum part tooth width	(mm)	60	
Maximum main spindle stroke width	(mm)	70	
Maximum main spindle stroke speed	(str/min)	1800	
Cutting speed	(m/min)	130	
Width	(m)	(Type I) 2.71	(Type II) 2.21
Depth	(m)	2.52	3.19
Floor space	(m^2)	6.8	7.0
Height	(m)	2.72	2.72
Main motor output	(kW)	7.5	
Machine mass (approximate)	(t)	7.5	

2.2 Measures against chips in dry cutting

In wet cutting, the coolant automatically cleans the cutting point, cools the workpiece and cutting tool, and discharges chips. The SE25A uses air blowing and stainless guard technologies established in hobbing machines, sealing the work area as shown in **Fig. 1**, and covering the bed surfaces with a sharply angled stainless steel cover having a small frictional coefficient to prevent chips from accumulating. Fallen chips are immediately discharged from the machine by a centrally mounted chip conveyor below the bed, preventing excess heat build-up.

2.3 Measures against machine vibration in high-speed cutting

A gear shaper vibrates easily because it uses a crank motion to reciprocate the tool. The SE25A has improved rigidity and a new balancer shaft (**Fig. 2**) for the driving system. Thereby allowing effective use of Super Dry II cutters and reducing noise and vibration. This realized a main spindle speed of 1800 str/min versus the conventional 1500 str/min and a maximum cutting speed of 130 m/min versus the conventional 90 m/min, reducing the vibration amplitude to one-sixth of the conventional.

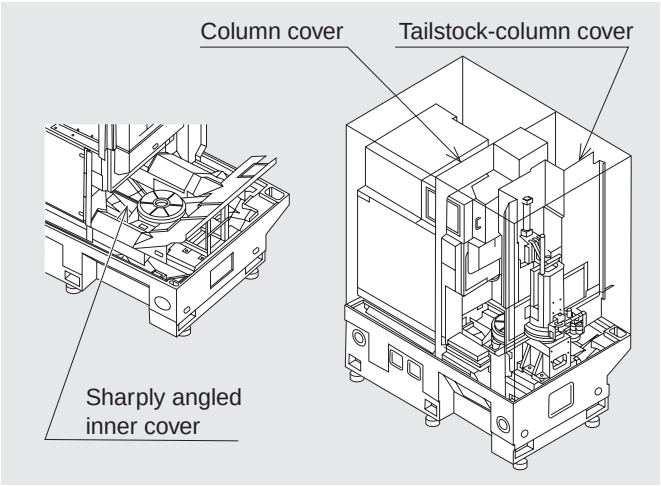

Fig. 1 Cover for preventing chips from escaping and accumulating
The work area is sealed and the bed top covered with a sharply angled stainless steel cover.

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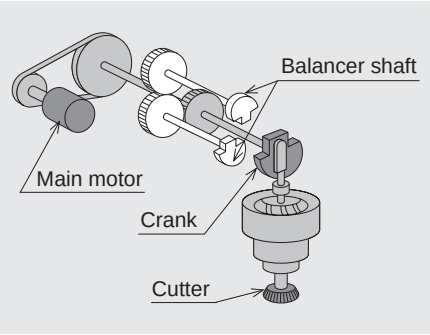

Fig. 2 Reduction of machine vibration using balancer shaft
Vibration amplitude is one-sixth of the conventional machine.

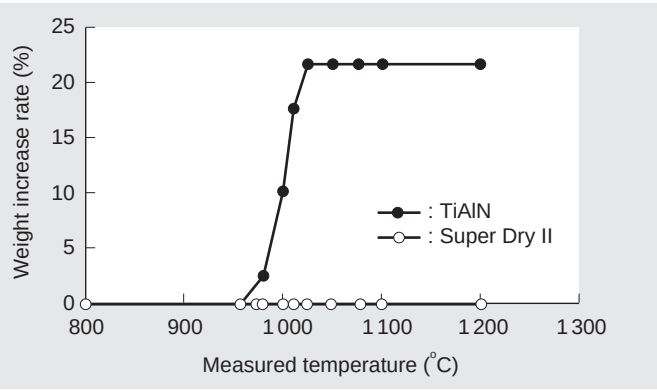

Fig. 3 High-temperature oxidation characteristics
This figure indicates the weight increase caused by film oxidation at high temperature. Super Dry II does not get oxidized even at 1 200 °C.

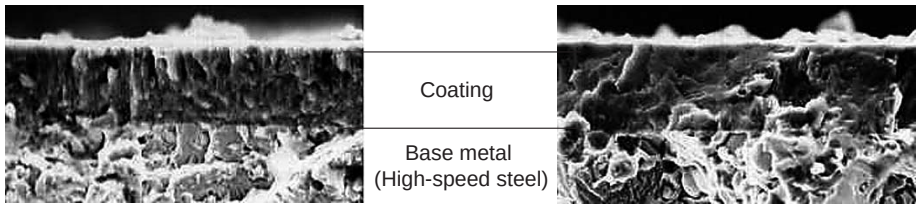

Fig. 4 Film cross-section
Super Dry II forms a dense film.

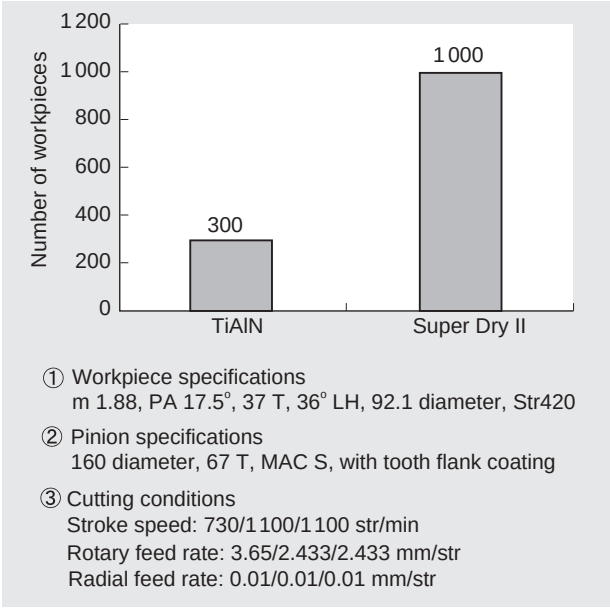

Fig. 5 Example of high production cutting using pinion cutter

3. Super Dry II Coating features

3.1 High-temperature oxidation resistance

Super Dry II Coating (hereafter "Super Dry II") was developed as a dry cutting tool for the advanced dry-cutting E series machines and features robust oxidation resistance at high temperatures. **Fig. 3** shows results of high-temperature oxidation tests comparing Super Dry II to conventional TiAlN coating. The temperature causing film oxidation is measured using the weight increase caused by oxidation when the environmental temperature rises. TiAlN starts oxidizing at around 980ºC, with the weight increase becoming constant above 1 000ºC, indicating oxidation saturation. Super Dry II shows no weight increase even at 1 200ºC, demonstrating its extremely high oxidation resistance compared with TiAlN.

3.2 Crystal structure

Fig. 4 shows cross-sections of TiAlN and Super DryII. TiAlN shows crystal grains pillars forming vertically against the substrate - typical of conventional Ti films of TiN and TiC. Super Dry II, in contrast, consists of microfine crystal grains forming a dense film ensuring excellent resistance to high-temperature oxidation and wear.

3.3 Example of mass cutting

Fig. 5 shows an example of high production cutting using a Super Dry II pinion cutter. The workpiece used for dry cutting was SCr420 with m 1.88, PA 17.5º, Z 37, β 36ºLH, and 92.1 diameter. Super Dry II tool life is 1 000 workpieces versus 300 for TiAlN.

4. Conclusions

The advanced dry cutting gear shaper SE25A and Super Dry II have further improved the gear shaping environment and reduced shaping cost. MHI, as the sole domestic manufacturer of gear cutting machines and tools, is continuously working to improve, upgrade, and advance gear hobbing and shaping with higher added value by means of their synergic effects.


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