Coated Cermet Grade T2500Z for Steel Turning

Kosuke FUKAE*, Takato YAMANISHI, Kazuhiro HIROSE, and Shinya IMAMURA

Cermet tools, characterized by low affinity with steel, realize high-quality finished surfaces in steel cutting and are commonly used for finishing. In the automobile, industrial machinery, and other manufacturing industries, high machining efficiency has become important year by year for lessening the environmental impact and machining costs. In increasingly severe machining conditions resulting from the pursuit of high efficiency, cermet tools are strongly required to offer long tool life and high-quality finished surfaces. Under such circumstances, we have developed and launched "T2500Z," a new cermet grade that features a long tool life and excellent finished surface quality. The T2500Z has twice the tool life of our conventional steel-turning grades, thus making it possible to meet user needs for high efficiency.

Keywords: cutting tool, coated cermet, turning, PVD

1. Introduction

Regarding inserts for cutting tools, grades coated with a hard ceramic film on the surface of a cermet*[1] substrate (hereinafter referred to as "coated cermets") attain a high-quality machined surface compared to other tool grades such as cemented carbide. They account for 15 to 20% of all tool grades and constitute an important part of the market.

Recently, in manufacturing industries such as automobiles and industrial machinery, the machining efficiency of steel in particular has been increased rapidly to reduce the environmental impact and machining costs.

However, tools have been used in severe conditions, and tool life has decreased significantly due to the increased efficiency. Thus, users have strongly expressed the need to improve tool performance.

In terms of the tool grades, coated cermets are widely used in finish machining. It is necessary to attain a long tool life that withstands high-efficiency machining and ensures good machined surface quality.

To meet such market needs, we worked on the development of a coated cermet tool for steel machining. We developed and marketed T2500Z, a new grade of PVD*[2] coated cermet that achieves a long tool life and excellent machined surface quality. This paper reports the development process and performance of this product.

2. Development of T2500Z

2-1 Applications for our cermet grades

Figure 1 shows the lineup of our cermet grades for turning. The uncoated cermets T1000A and T1500A are used for high-speed continuous machining and low-speed interrupted machining. T1500Z and T2500Z are coated cermets.

While uncoated cermets are suitable when placing top priority on machined surface quality with low tool cost, coated cermets are suitable when importance is attached to reducing damage to tools such as wear and fracture.

For T2500Z, we have 539 items in total in our inventory as inserts for ISO*[3] turning and grooving inserts. An extensive lineup meets the diverse machining needs of users.

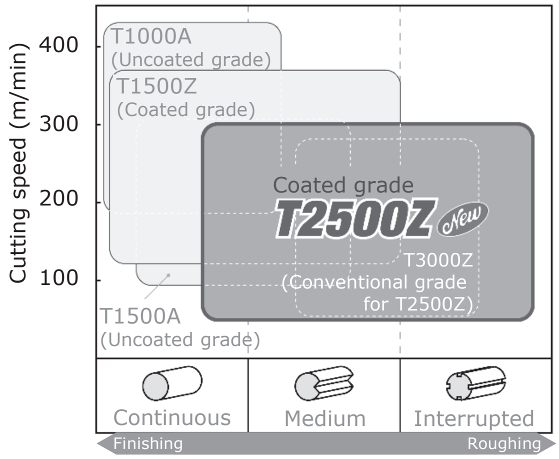

Fig. 1. Application for cermet grades for turning

2-2 Development goals of T2500Z

To set clear development goals for this next-generation product, we collected inserts used in the market and analyzed the damage by observing the cutting edge of the inserts. It was found that, in the machining of various types of steel materials such as alloy steel and steel sheet materials, chipping of the cutting edge very often led to fracture, resulting in the end of tool life.

For this reason, we set the goal of increasing fracture resistance by twice or more while maintaining excellent machined surface quality and wear resistance, and we launched the development project.

3. Features of T2500Z

3-1 Efforts to improve fracture resistance

To improve fracture resistance against thermal load in particular, we focused on the thermal shock resistance*[4] of the cermet substrate.

In a machining process where an insert comes into contact with a work material interruptedly (Fig. 2), the cutting edge of the insert is subject to a repeated cycle of friction with the work material and then idling. This causes the temperature to increase and decrease rapidly.

In other words, the cutting edge is subject to a repeated cycle of thermal expansion and thermal contraction. Cracks are generated because the insert cannot withstand the temperature changes, eventually resulting in fracture (see Fig. 3).

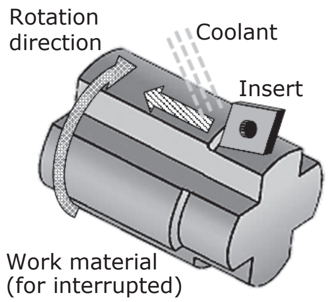

Fig. 2. Schematic diagram of interrupted machining

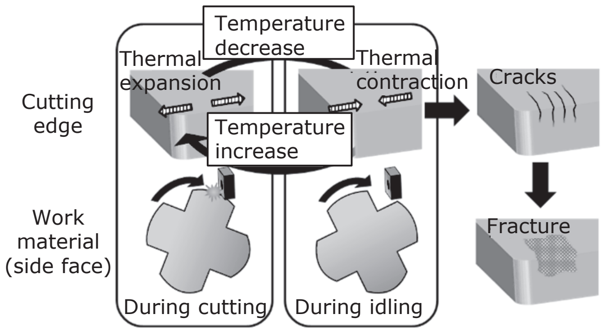

Fig. 3. Mechanism of fracture due to thermal shock

We considered that thermal shock resistance was closely related to the fracture mechanism. Thus, we regarded thermal shock resistance as an important index in the development process.

We developed a new cermet substrate with superb thermal shock resistance and applied it to T2500Z. Figure 4 shows the cross-sectional structures of cermet substrates of a conventional grade and T2500Z.

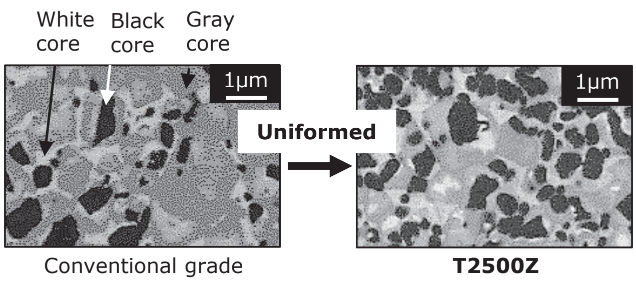

Fig. 4. Cross-sectional structures of conventional and T2500Z substrates

The cermet substrate consists of a hard phase, which is composed of black cores and gray cores, and a binder phase, which is composed of white cores. The black cores are the titanium (Ti) carbonitride phase. The gray cores around the black cores are the carbonitride phase composed of Ti, tungsten (W), niobium (Nb), and other elements.

T2500Z is manufactured by increasing the ratio of the black cores, which are characterized by superb thermal conductivity, and by densely and uniformly granulating the entire microstructure.

We succeeded in improving thermal shock resistance by 75% compared to the conventional grade while maintaining the hardness equivalent to that of the conventional grade (Fig. 5). This led to the improvement of fracture resistance, as set in the goal.

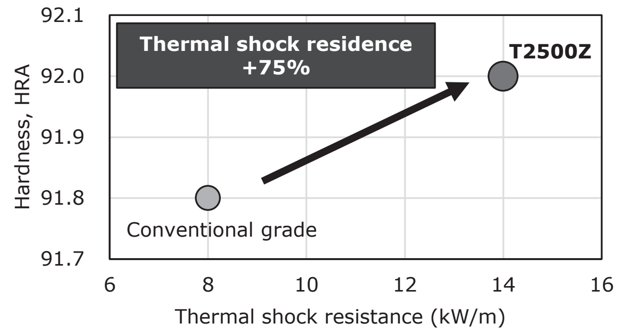

Fig. 5. Correlation between hardness and thermal shock resistance

3-2 Application of Brilliant Coat

Brilliant Coat is our proprietary PVD coating. The technology is used for the T1500Z.[1] The cross-sectional structure of Brilliant Coat is shown in Fig. 6. It consists of two layers: a lubrication layer and a high-wear resistance layer (in order from the surface).

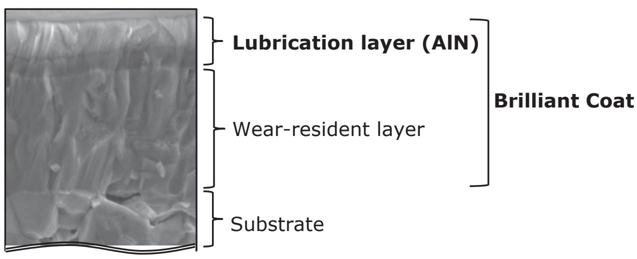

Fig. 6. Cross-sectional structure of Brilliant Coat

The lubrication layer consists of an aluminum nitride (AlN) layer characterized by superb lubricity, high sliding properties, and outstanding reactivity resistance against steel. Thus, the layer significantly improves the finish surface quality.

The highly wear-resistant layer underneath the lubrication layer enables the cutting edge to achieve stable and high wear resistance.

Expansion of the application to T2500Z has made it possible to market T1500Z/T2500Z as a series of coated cermet grades using Brilliant Coat.

3-3 Cutting performance

We used T2500Z to conduct a fracture resistance test by performing interrupted turning of alloy steel. The results are shown in Fig. 7. The results demonstrate a tool life double or more of the conventional grade due to the application of the new cermet substrate.

Similarly, a wear resistance test was conducted by continuous turning of alloy steel. Figure 8 shows the results. The wear resistance was 1.5 times that of the conventional grade due to the application of Brilliant Coat.

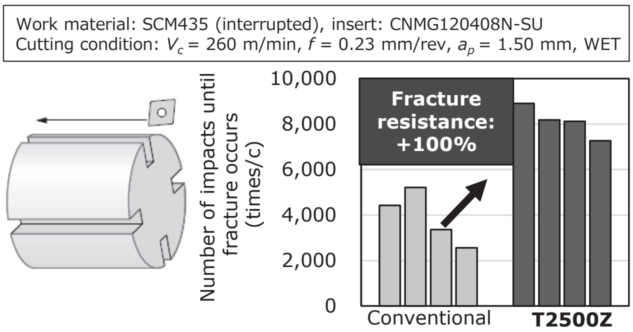

Fig. 7. Fracture resistance evaluation results for T2500Z

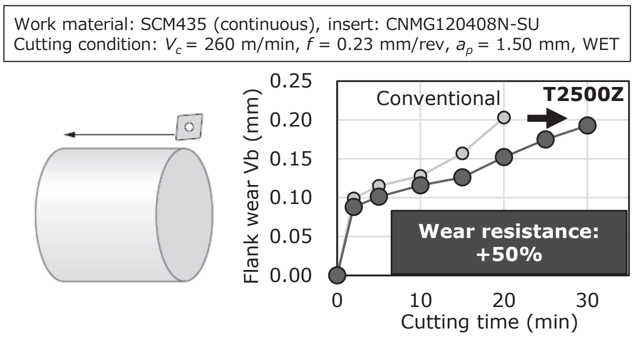

Fig. 8. Wear resistance evaluation results for T2500Z

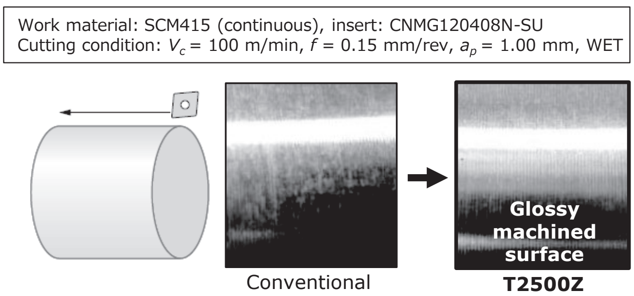

Fig. 9. Machined surface quality evaluation results for T2500Z

The influence of T2500Z on the machined surface quality was evaluated. The results are presented in Fig. 9. Cloudiness caused by tearing on the machined surface was reduced compared to the conventional grade due to the lubrication effect of Brilliant Coat, achieving an extremely beautiful machined surface.

4. Examples of Machining Using T2500Z

Examples of machining by our users with T2500Z are presented in Figs. 10 to 13.

Figure 10 shows an example of machining of an automotive part (sheet steel material). T2500Z demonstrated superb wear resistance due to Brilliant Coat. The tool life was 2.5 times that of conventional grade.

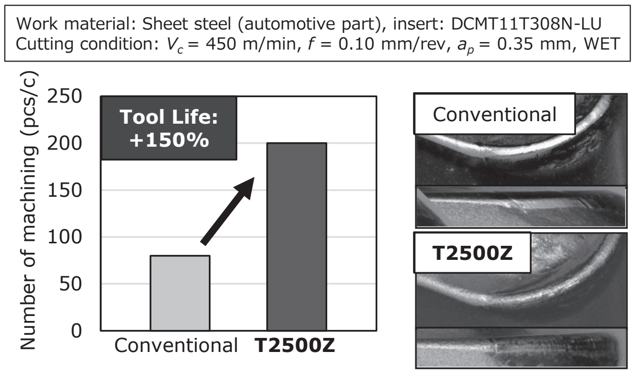

Fig. 10. Example of machining using T2500Z ①

Another example of machining an automotive part (SAPH440) is presented in Fig. 11. T2500Z demonstrated superb wear resistance, and the tool life was double that of conventional grade due to reduced notch wear.

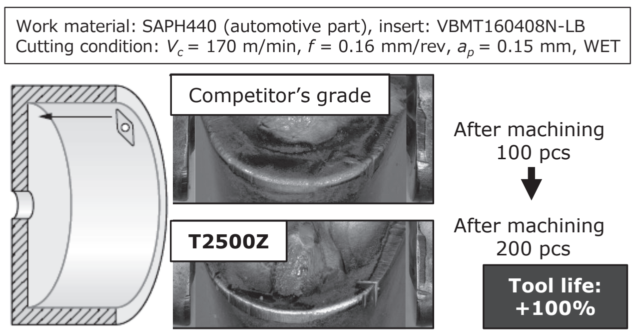

Fig. 11. Example of machining using T2500Z ②

Figure 12 shows an example of machining a bar material (SCM435). T2500Z demonstrated superb wear resistance due to Brilliant Coat, achieving a tool life 1.9 times that of conventional grade.

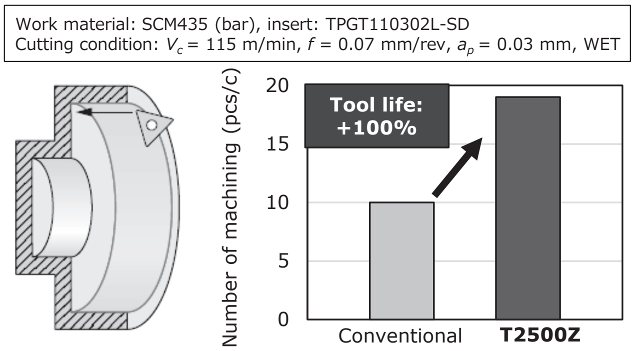

Fig. 12 Example of machining using T2500Z ③

An example of machining a bolt (S45C) is presented in Fig. 13. T2500Z demonstrated superb fracture resistance due to the use of a new cermet substrate. The tool life was up to 2.5 times that of conventional grade.

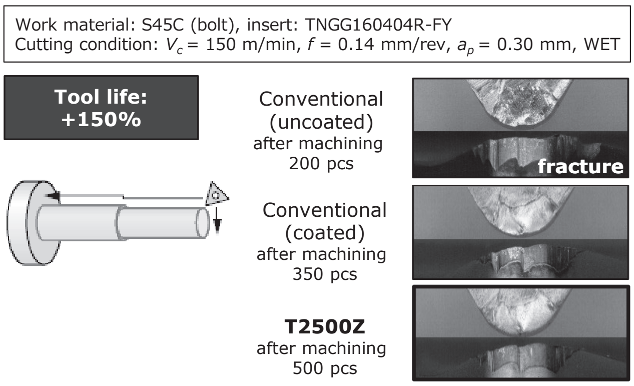

Fig. 13 Example of machining using T2500Z ④

5. Conclusion

This paper reported the development process of T2500Z, a coated cermet for steel turning, and cutting examples.

Derived from the use of a newly developed cermet substrate and application of Brilliant Coat, T2500Z achieved a tool life double that of conventional grade while demonstrating excellent machined surface quality.

Our coated cermets for steel turning have been renewed as the Brilliant Coat series including T1500Z. We believe that these products will contribute greatly to increasing efficiency and reducing machining costs by users.

Technical Terms

∗1 Cermet: Cermet is a coined word taken from ceramic and metal. It is a composite material derived from mixing a Ti-based hard compound with a metallic binder and sintering the mixture.

∗2 PVD: PVD is an abbreviation for physical vapor deposition. A target material is ionized by arc discharge or other methods and is deposited on a base material as a ceramic film through reaction with a gas.

∗3 ISO: ISO is an abbreviation for International Organization for Standardization. The standards including the shapes and dimensions of inserts are indicated using ISO graphical symbols.

∗4 Thermal shock resistance: Thermal shock resistance is an index that shows the durability of a material against a thermal impact load. It is calculated based on the following formula.

$$R = (\lambda \cdot \sigma)/E \cdot \alpha$$

R: thermal shock resistance (kW/m), λ: thermal conductivity (W/m·K), σ: flexural strength (GPa), E: Young’s modulus (GPa), α: thermal expansion coefficient (× 10^{-6}/K)

Reference

(1) S. Koike, K. Hirose, K. Tsuda and K. Yamagata, “Brilliant Coat Cermet T1500Z for Steel Turning,” SEI Technical Review, No. 78, pp. 90-94 (January 2014)

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