# Development of Cermet "T1500A" for Steel Turning

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Sumitomo Electric Hardmetal Corporation and Sumitomo Electric Industries, Ltd. have developed a new cermet "T1500A" for steel turning. In turning operations, improvement of work efficiency by introducing high-feed or high-speed processing is important. Meanwhile, in the precision processing of electric and electronic machine parts, improvement in machining accuracy and surface quality are desired. Under such circumstances, T1500A has been developed to satisfy these requirements. T1500A features high hardness and toughness because of the unique microstructure of its substance material consisting of fine, hard particles based on Ti (C,N) and tough particles based on carbonitride compounds. Refining these particles and introducing a new edge treatment technology improved the quality of surface finishing. Furthermore, optimization of the balance between wear resistance and toughness allowed T1500A to have a wider application range than that of the conventional cermet. Thus, T1500A's outstanding reliability in finishing can contribute to processing cost reduction and production improvement.

Keywords: cermet, steel turning, finish cutting

## 1. Introduction

In the field of turning, there have been increasing demands for high-accuracy machining for precision components used in electric and electronic devices as well as high-speed and high-efficiency machining for automobile and other industrial equipment. To meet these demands, cutting tools that can be used in harsh environments without shortening the tool life and increasing the total processing cost are increasingly required. Under such circumstances, the conventional materials of turning tools, such as cemented carbide and cermet, have gradually been replaced by coated materials, such as coated cemented carbide and coated cermet. However, cermet still accounts for 15-20% of all materials used for the tools. It is expected that this ratio will remain unchanged in the future; cermet tools that can realize high-quality finishing will hold a leading position among the turning tools. Cermet, mainly composed of titanium, contains a smaller amount of tungsten, a rare metal, than cemented carbide. This makes cermet advantageous from the viewpoint of resource conservation.

T1500A is a steel turning tool that has been improved in the stability of finishing and the balance between wear resistance and fracture resistance while fully utilizing the characteristics of the cermet material. In this paper, the characteristics and cutting performance of the T1500A tools are described.

## 2. Demands for Cermet Tools

In steel turning, in general, work pieces are roughened first using a coated cemented carbide tool with a high fracture resistance, and then finished using a cermet tool with a low chemical affinity to steel. In some cases, the cermet tool is used throughout from roughing to finishing. Requirements for the cermet tools used in finishing are high dimensional accuracy of the work and high quality of the finished surface (low surface roughness, good physical appearance and reduction of tear on the work). It is necessary to improve the wear resistance in order to maintain a high dimensional accuracy; therefore, improvement in the wear resistance and the quality of the finished surface is the key task.

## 3. Development of T1500A

### 3-1 Various cermet materials manufactured by Sumitomo Electric Hardmetal Corp.

**Figure 1** shows the lineup of various cermet materials for steel turning manufactured by Sumitomo Electric

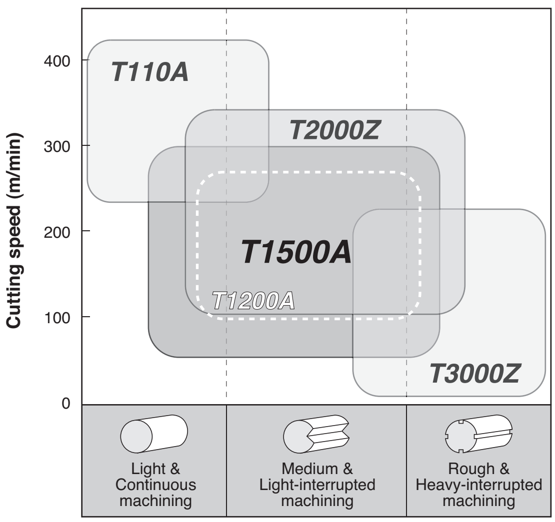



**Fig. 1.** The lineup of various cermet materials for steel turning

Hardmetal Corporation. Non-coated cermet materials, T110A and T1500A, and coated cermet materials, T2000Z and T3000Z, cover a wide range of applications from high-speed continuous turning to low-speed interupted turning of steel parts.

The improved balance between wear resistance and toughness allowed T1500A to have a wider range of applications than that of conventional cermet materials. A performance comparable to that of coated materials is expected, depending on the cutting environment.

**3-2 Development target of T1500A**

High dimensional accuracy of the work and high quality of the finished surface are required for cermet tools used in finishing. Therefore, the development goal of T1500A is to improve wear resistance and fracture resistance as well as the quality of the finished surface through the development of its base material and technology for processing cutting edges.

## 4. Characteristics of T1500A

**4-1 Characteristics of base material**

**Figures 2** show scanning electron microscopy (SEM) images of the structures of the conventional material (a) and T1500A (b). As shown in **Fig. 2(a)**, the conventional material has a hard phase with a double structure and a bonded phase. The black core is rich in titanium carbonitride, and is covered by a gray phase composed of carbonitride solid solutions, such as titanium, tungsten and niobium. The particles with a large area of black core have high hardness and wear resistance, whereas the particles with a large area of gray phase have high toughness.

In contrast, T1500A is characterized by its structure with the following four types of hard phase with different particle sizes and compositions, as shown in **Fig. 2(b)**: (1) hard phase of a double structure with a black core, as observed in the conventional material, (2) single hard phase composed of fine black titanium carbonitride particles, (3) hard gray phase of solid-solution carbonitride, and (4) hard phase of a double structure with a light-gray core rich in tungsten.

In the conventional material, the binder phase region (white) composed of Co and Ni existing around hard phases is obvious and the binder phase is thick in some regions. However, in T1500A, hard black phases composed of fine particles (2) are scattered in the binder phase, and there is no region with a thick binder phase. These hard black phases are composed of TiCN; the existence of these phases improves the wear resistance as well as toughness owing to the suppression of the development of cracks. Furthermore, in T1500A, the wear resistance observed in the conventional material is maintained while toughness is further improved because of the coexistence of the hard phase of a double structure with the black core as seen in the conventional material (1), the hard phase of a double structure with the light-gray core (4), and the single hard gray phase (3).

**Figure 3** shows the relationships between fracture toughness (K1c) and Vickers hardness (Hv) for the four materials, i.e., conventional material, T1500A, only fine particles of the hard phase with the same composition as that of T1500A (hereafter, fine hard particles), and only coarse particles of the hard phase with the same composition as that of T1500A (hereafter, coarse hard particles).

As shown in **Fig. 3**, when fine hard particles are used, hardness is high but fracture toughness is low; in contrast, when coarse hard particles are used, fracture toughness is high but hardness is low. As explained, the toughness and hardness of T1500A are increased with the presence of the high-toughness hard phase and the binder phase including fine hard-phase particles, respectively. The Vickers hardness and fracture toughness of T1500A are higher than those of the conventional material or a material in which uniform size hard particles are distributed.

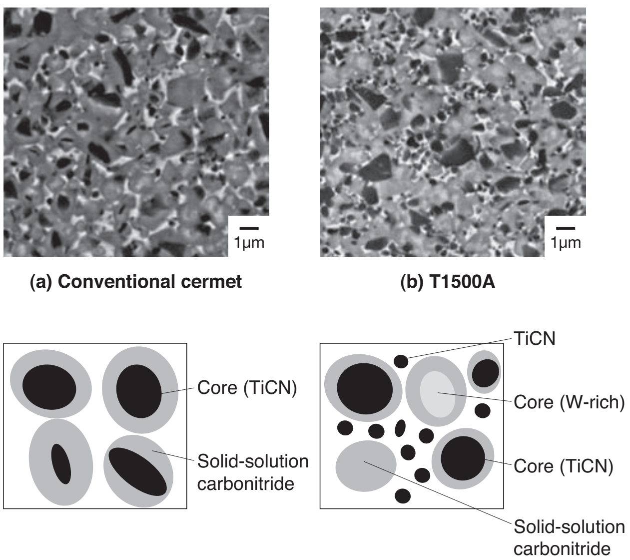



**Fig. 2.** Structures of the conventional cermet and T1500A

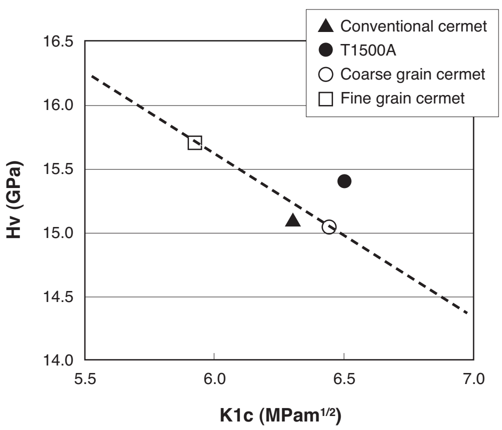
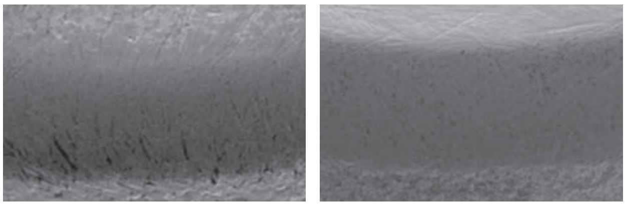



**Fig. 3.** Relationships between fracture toughness (k1c) and Vickers hardness (Hv)

### 4-2 Characteristics of insert edge

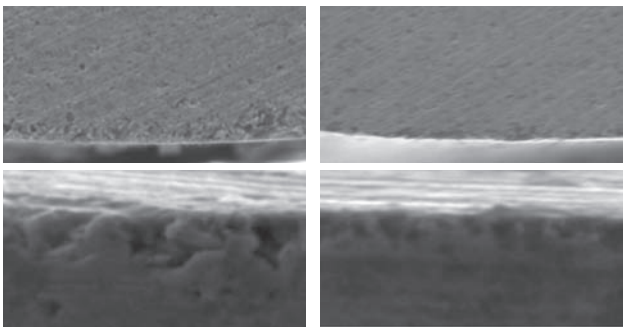
There are two types of cermet tools; one has edges treated such that edge ridges are rounded, and the other is a sharp edged (grinded class) tool without rounding and is used for finishing in precision cutting. When inserts are treated by the conventional edge treatment method, scratches remain on the edge surface, as shown in **Photo 1(a)**, which cause an adverse effect on the surfaces finished with these inserts. In contrast, the edge of the T1500A insert was treated by a smooth edge treatment technique that we developed; the surface subjected to this edge treatment has negligible scratches and is smooth, as shown in **Photo 1(b)**.

For the sharp edged (grinded class) insert, removal of the hard particles from the edge is suppressed, as shown in **Photo 2**, by the miniatualization of fine hard-phase particles with high hardness and wear resistance, and the improvement of the toughness of the alloy, leading to high edge sharpening performance.



**(a) Conventional edge treatment** **(b) T1500A's edge treatment**

**Photo 1.** Comparison of the conventional and T1500A's edge treatment



**(a) Edge of conventional cermet** **(b) T1500A's edge**

**Photo 2.** Comparison of the states of conventional cermet edge and T1500A's sharp edge

## 5. Cutting Performance of T1500A

### 5-1 Wear resistance

Compared with the conventional cermet material, T1500A has a high wear resistance with suppressed irregularity in wear because of the existence of a single hard phase composed of fine TiCN particles in the bonded phase. **Figure 4** shows the results of the wear resistance test. As shown

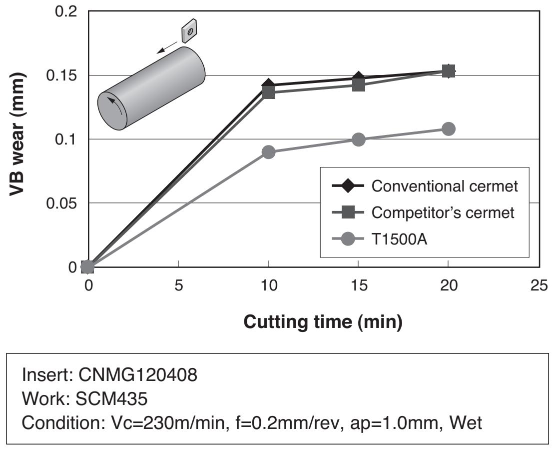
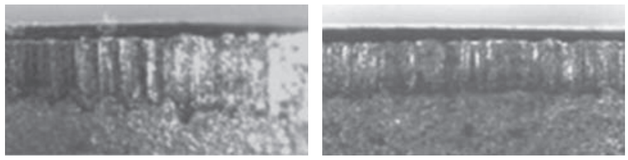



**Fig. 4.** Evaluation results on wear resistance



**(a) Conventional cermet** **(b) T1500A**

**Photo 3.** Edge states after wear resistance test

in the figure, T1500A exhibits a high wear resistance.

**Photos 3** show the photographs of wear at the flank surface for the conventional material (a) and T1500A (b). The irregularity in wear is suppressed and the wear pattern is smooth in T1500A compared with those in the conventional material. This is because the hard particles, which are advantageous for improving the wear resistance, are fine and suppress the removal of the particles from the worn region.

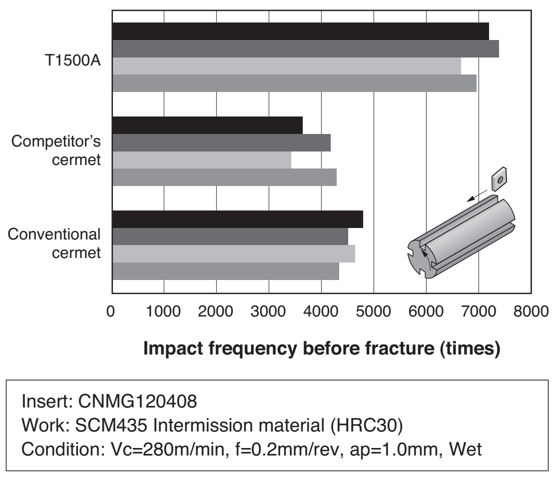



**Fig. 5.** Evaluation results on fracture resistance under interrupted machining

**5-2 Breakage resistance**

Cermet tools are mainly used for finishing. They are frequently used not only for continuous cutting of low depth but also finishing including interupted cutting. Fracture resistance is a particularly important factor in interupted cutting. The results of the fracture resistance evaluated by cutting a grooved work are shown in **Fig. 5**.

T1500A exhibited high fracture resistance and enables stable cutting compared with the conventional cermet and the competitor's.

**5-3 Finished surface**

In finising with cermet tools, the quality of the surface finish (surface roughness, tear and luster of the finished surface) of the work is especially important. Wear resistance as well as the properties of the treated edge may affect these factors. The physical appearance of the machined surface and luster is important. An example of an indicator of the physical appearance is the shape within the cutting mark of the work; the smaller the irregularity in the cutting mark, the better the surface obtained.

The surface of the work finished using the T1500A tool was evaluated on the basis of the above points. **Figures 6** show the photographs and morphological data of the cutting marks on the surfaces finished using tools composed of the conventional material (a) and T1500A (b). The surface finished with the T1500A tool was hardly torn and the shape within the cutting mark is uniform. In addition, the 10-point average roughness (Rz) is small, and good surface smoothness can be obtained. As already explained, the change in surface roughness over time is limited when the T1500A tool is used because it has better wear resistance than the tool composed of the conventional material.

By using T1500A as a material for tools, a finished surface with improved surface roughness can be stably obtained in finishing.

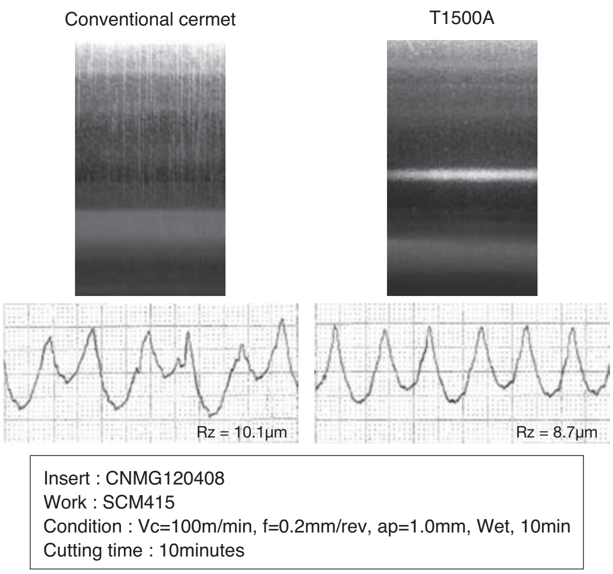



**Fig. 6.** Evaluation results on finished surface

## 6. Examples of the Application of T1500A

Examples of the application of T1500A are described below.

**6-1 Application of M-class inserts**

**Figure 7** shows the use of the M-class T1500A tool for the cutting of Chromium-Molybdenum steel (JIS: SCM415 and SCM435). The main reason for the end of tool life is the deterioration of the cut surface. The torn surface of the work is suppressed compared with the case of using the competitor's tool. Because of the suppression of the torn surface, the cut surface of the work becomes stable, enabling the extension of tool life by a factor of 1.6-3.

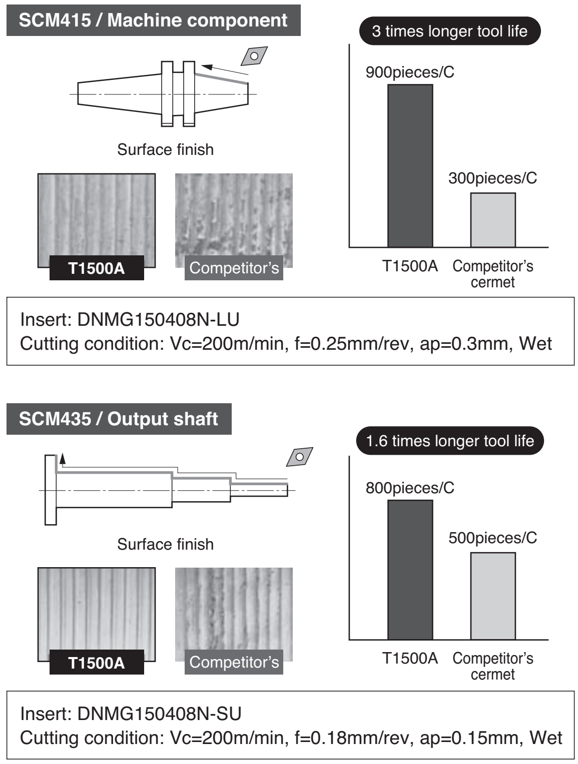



**Fig. 7.** The application of M-class T1500A

**6-2 Application of G-class inserts**

**Figure 8** shows the application of the G-class T1500A tool. Tools used for cutting pressed materials easily wear, and it is difficult to finish thin pressed materials. In cutting a pressed material (SAPH400) (**Fig. 8**, upper), a good finished surface can be obtained consistently using the T1500A tool, and the amount of wear is significantly reduced, leading to an increase in the possible number of cuttings per cutting corner by twofold compared with the case of using the competitor's cermet.

For end face cutting of the S45C transmission parts (**Fig. 8**, lower), wear resistance is improved by adopting a sharp edge tip, and a tool lifetime of 1.6-fold that of the competitor's cermet, is obtained.

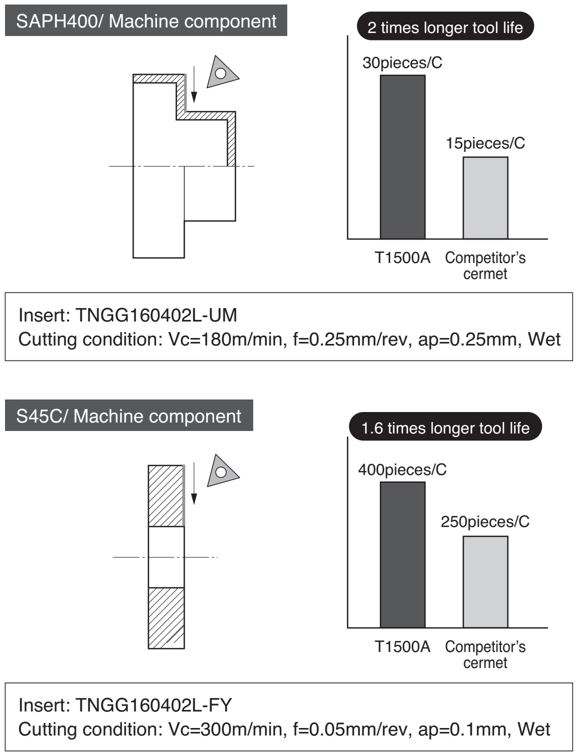



**Fig. 8.** The application of G-class T1500A

## 7. Conclusion

T1500A has high wear resistance and fracture resistance, and can be used as a material of the cermet tool to improve the quality of surface finishing. Compared with conventional cermet materials, T1500A is markedly stable. We believe that T1500A can contribute to the reduction of the machining cost and the improvement of production for users through outstanding reliability of the finishing operation.

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