

Development of New Coated Carbide Grade Ace Coat AC405K/415K for Cast Iron Turning

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Coated inserts are used in the cutting of automotive and other machine components. For the reduction of the environmental impact and efficient use of resources, these components have increasingly thin walls and complex designs, using high-strength, difficult-to-cut materials. Meanwhile, there is also a strong demand from machining sites for cutting tools that have a long tool life and exhibit stable performance. To satisfy these demands, Sumitomo Electric Hardmetal Corporation has developed new coated carbide grades "ACE COAT" AC405K/415K for cast iron turning. This paper describes the features and cutting performance of the new products.

Keywords: cast iron turning, CVD, TiCN, ductile cast iron

1. Introduction

Coated inserts are indexable inserts which have cemented carbide surfaces coated with a hard ceramic film and are used for cutting tools. Coated inserts are being increasingly used because of their better balance between wear and chipping resistances than that of other inserts, currently accounting for 70% of all indexable inserts⁽¹⁾.

Coated inserts are used in the cutting of various materials such as carbon steel, alloy steel, stainless steel, and cast iron. For each of these materials, various measures have been taken to reduce the environmental impact and efficiently use resources.

In the machining of cast iron components, for example, those used for automobiles, the reduction of the weight of components has been attempted with the aim of reducing exhaust gas emissions and improving fuel consumption. The wall thickness of components must be decreased to reduce their weight, making their shape more complicated. Components with a thin wall are also required to have sufficiently high strength. Owing to these requirements, workpiece materials are shifting from gray cast irons (hereafter, FC) to ductile cast irons (hereafter, FCD) with high strength and low workability, making cutting difficult. Therefore, machinability lowers significantly in terms of both shape and material.

On the other hand, from machining sites, the demand for high-speed and high-efficiency machining is increasing along with the increasing demand for low-cost machine tools with improved performance. Cast iron cutting tools are required to have high stability and a long tool life even under such severe requirements.

Sumitomo Electric Hardmetal Corporation has developed and released two new coated carbide grades to meet the above market requirements: Ace Coat AC405K for the high-speed continuous turning of cast iron and Ace Coat AC415K for general turning including continuous and interrupted turning. We report the development of these tools and their performance in this paper.

2. Purpose of Developing AC405K/415K

Figure 1 shows our coated inserts used for cast iron turning and their fields of application. Ace Coat AC405K can be used for high-speed continuous turning, Ace Coat AC415K can be used for general turning including continuous and interrupted turning, and Ace Coat AC420K⁽²⁾, which has been already released, can be used for casting surface and interrupted turning. Thus, the AC400K series can cover all fields of application from roughing to finishing and from continuous to heavily interrupted turning.

Before developing AC405K/415K, we collected used inserts from our customers that had been employed for cast iron turning and investigated their cutting conditions and states of damage. The types of damage to the inserts used in high-speed continuous turning and general turning including interrupted turning, which are the fields of

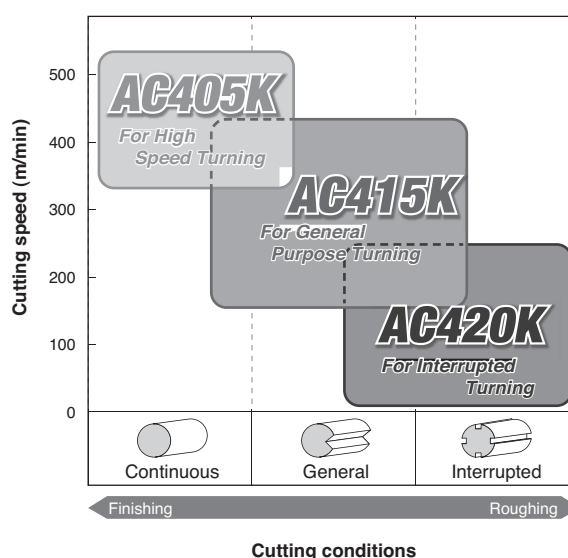

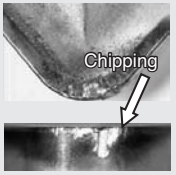
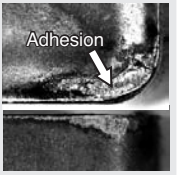


Fig. 1. Application range map of AC405K, 415K, 420K

application of AC405K/415K, were roughly classified into three groups, as shown in **Table 1**. The used inserts ultimately failed owing to any one of the three types of damage or their combination. In particular, damage due to wear, chipping, or their combination accounted for at least 80% of the damage leading to failure. Therefore, we developed AC405K/415K with the aim of reducing wear and chipping; at least 1.5 times higher wear and chipping resistance than those of conventional inserts.

Table 1. Types of damage to tools used for cast iron turning and their causes

	Wear	Chipping	Adhesion
Example of damage			
Causes	Insert is extremely worn because of rubbing with hard component particularly after coating has worn away. Particularly occurs in high-speed turning of FC materials.	Cutting edge is chipped during interrupted turning. Also occurs during continuous turning because of impact with micro asperity on casting surface.	Fine particles from soft component are pressed onto tool surface and firmly adhere owing to turning heat. Coating is removed from insert when the particles fall. Particularly occurs for FCD materials.
Required properties	Thick coatings with high hardness	Coatings with high strength and high stacking	Coatings with high stacking strength and smooth surface

3. Characteristics of AC405K/415K

3-1 Improved wear resistance by new coating technology

We adopted a new coating technology in the development of AC405K/415K. This technology was obtained by optimizing the control process of Super FF Coating Technology⁽³⁾, which is our conventional chemical vapor deposition (CVD)^{*1} coating technology for realizing fine crystal textures and flat and smooth surfaces. Among the coatings, the titanium carbon nitride (TiCN) layer deposited to increase wear resistance was much harder than the conventional coatings, as shown in **Fig. 2**, due to the significantly small grain with dense and homogeneous structure. **Figure 3** shows the comparison of wear behavior and damage of cutting edges, when ductile cast iron (FCD700) was subjected to continuous turning using conventional inserts and AC405K.

In a comparison of the damage after 19 min turning, the coating on the cutting edge was completely removed when using a conventional insert, whereas it was almost remained when using AC405K because of its high wear resistance, which suppressed the amount of damage. When the tool life is defined as the time until the flank wear reaches 0.25mm, AC405K serves at least 1.5 times longer than a conventional insert.

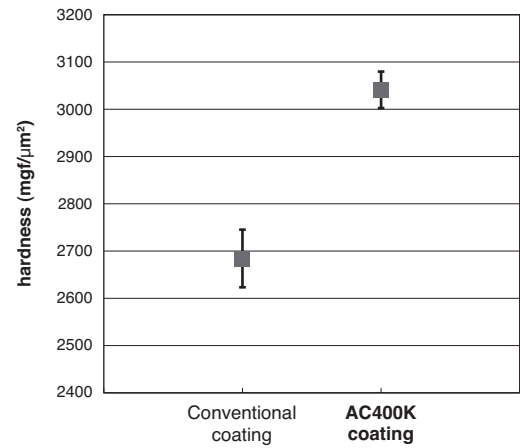


Fig. 2. The hardness of TiCN layer of conventional coating and AC400K coating

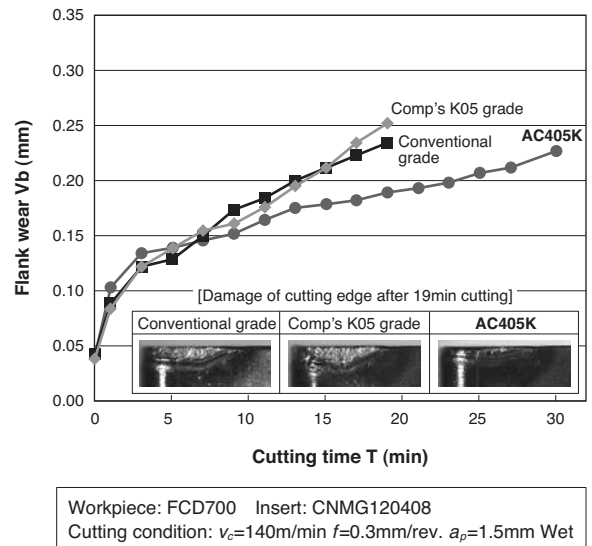


Fig. 3. Evaluation results on continuous cutting of ductile cast iron (FCD700)

3-2 Suppression of irregular damage by stress control technology

There are micro-patterned indented surface (fine asperity), burrs, sand inclusions, and chilled layers on the casting surfaces (as-cast surface) of most cast iron workpieces because of the production method. When as-cast surface is removed by cutting, the cutting edge suffer adhesion and micro-chipping as shown in **Photo 1**, which results in the increased occurrence of sudden breakage. Moreover, the interrupted turning of complicated shapes, which is characteristic of cast iron, will further increase damage due to chipping and make it more difficult to guarantee a long tool life.

In the AC405K/415K, part of the residual tensile stress specific to CVD coatings was successfully transformed to compressive stress by employing a technology for controlling the internal stress of the coatings. The

chipping resistance of AC405K/415K was markedly improved from that of an insert with a conventional coating, as shown in Fig. 4. In addition, by an advanced surface treatment to create a high oxidation-resistant and adhesion-resistant α -alumina (Al_2O_3) layer as the outermost layer, chipping caused by adhesion of the workpiece components during turning was also suppressed. Thus, the

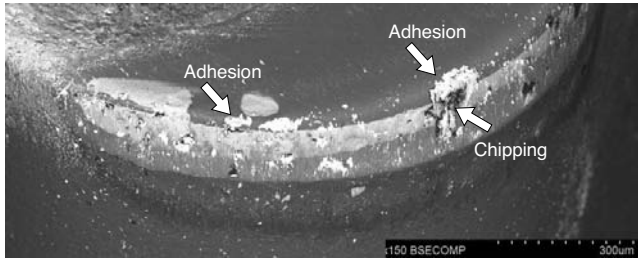


Photo 1. Initial damage of cutting edge for casted surface cutting

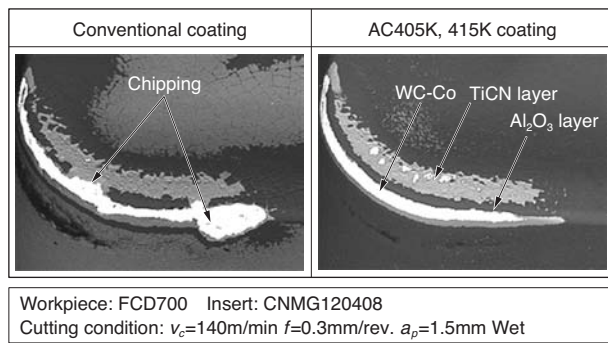


Fig. 4. Suppression of chipping with internal stress control

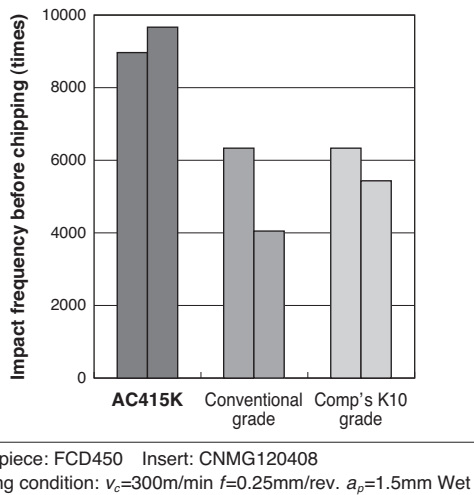


Fig. 5. Evaluation results of chipping resistance under interrupted cutting

chipping resistance of AC405K/415K during high-speed turning was improved to at least 1.5 times higher than that of a conventional insert, as shown in Fig. 5, markedly improving the tool reliability and the stability of the tool life.

4. Cutting Performance of AC405K/415K

4-1 Application examples of AC405K

Figures 6 and 7 show examples of turning using AC405K. Figure 6 shows an actual use result of AC405K in outer diameter finishing turning of a gray cast iron (FC200). By using AC405K with high wear resistance, high-speed dry turning with a cutting speed of 500m/min was possible for 1.5 times longer than using a conventional insert. Moreover, chipping due to wear was not observed on the cutting edge even after this extended turning; thus, stable turning operation was achieved.

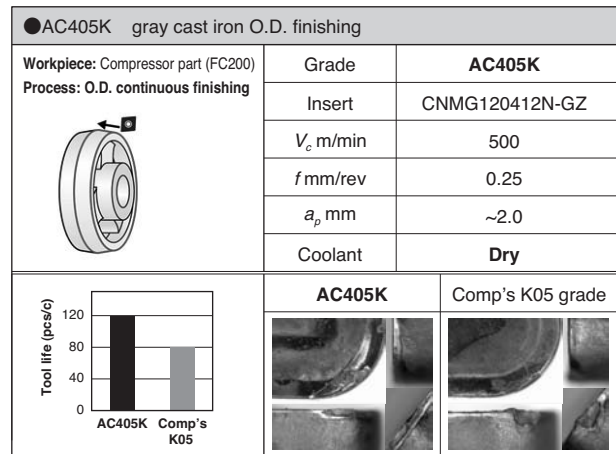


Fig. 6. Actual use result of AC405K on gray cast iron turning

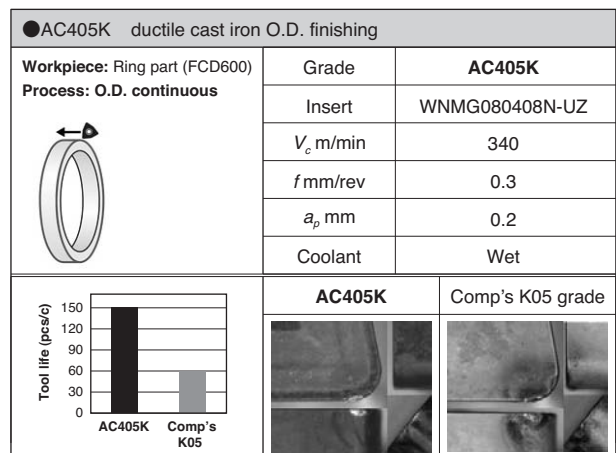


Fig. 7. Actual use result of AC405K on ductile cast iron turning

Figure 7 shows actual use result of AC405K in outer diameter finishing turning of a ductile cast iron (FCD600). The tool life when using the conventional insert was unstable because of the existence of as-cast surface, whereas the tool life when using AC405K was 2.5 times longer than that using a conventional insert because of the suppression of chipping and the improved wear resistance.

4-2 Application examples of AC415K

Figures 8 and 9 show examples of turning using AC415K. Figure 8 shows an actual use result of AC415K in face roughing turning of a gray cast iron (FC200). When unstable as-cast surface was turned at a high cutting speed of 450m/min, the tool life using AC415K with high wear resistance was 1.4 times longer than that using the conventional insert.

Figure 9 shows an actual use result of AC415K in outer diameter roughing turning of a ductile cast iron (FCD600). Although the turning conditions were very unstable because as-cast surface existed and the machining process in-

cluded interrupted turning, the tool life using AC415K was 1.6 times longer than that using the conventional insert. Irregular damage was observed on the cutting edge obtained after turning using the conventional insert because of chipping, whereas only a normal amount of damage was observed on the cutting edge obtained after turning using AC415K.

5. Conclusion

The wear resistance of AC405K/415K was improved by employing a new coating technology, and irregular damage was suppressed by a technology to control the stress, enabling high-speed stable turning using AC405K/415K. We believe that the AC400K series, consisting of these two new grade and AC420K for interrupted turning, will greatly contribute to reducing the machining cost and increasing the productivity of our customers in a wide range of applications from high-speed turning to interrupted turning of cast iron.

· Ace Coat and Super FF Coating are trademarks or registered trademarks of Sumitomo Electric Industries, Ltd.

Technical Term

*1 CVD (Chemical vapor deposition): One of the coating methods for forming ceramic coatings using a chemical reaction.

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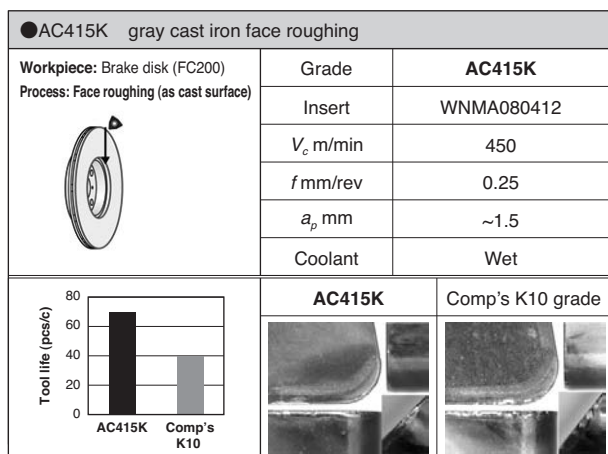


Fig. 8. Actual use result of AC415K on gray cast iron turning

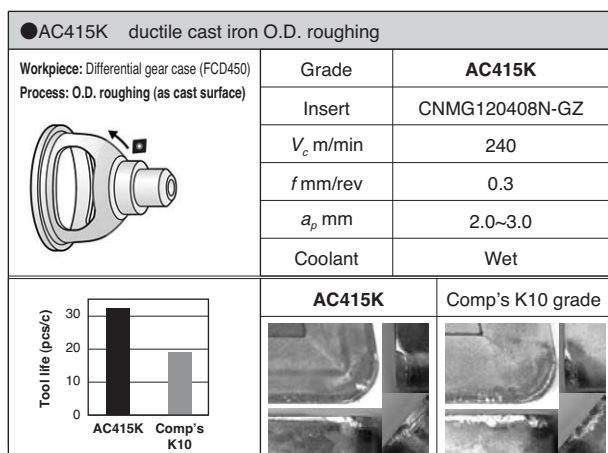


Fig. 9. Actual use result of AC415K on ductile cast iron turning

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