SUMITOMO ELECTRIC TECHNICAL REVIEW

New Coated-Carbide Grade AC8115P for High-Speed Steel Turning

Masahito HIKIJI*, Atsuhiro YONEDA, Takato YAMANISHI, and Hideaki KANAOKA

Efforts are underway in the steel machining, particularly in the automotive industry, to reduce the environmental impact and to enhance resource efficiency. We introduced the AC8000P series for steel turning in 2016, featuring the new chemical vapor deposition (CVD) coating technology "Absotech," and have since expanded our product range. In recent years, there has been a growing trend in steel turning especially toward reducing machining time and transitioning to dry cutting without the use of cutting fluids. In response to this trend, we have developed AC8115P, a new steel turning carbide grade designed for high-efficiency and dry cutting applications. AC8115P demonstrates outstanding performance by addressing the challenges of high cutting-edge temperatures, effectively minimizing tool wear and plastic deformation. This grade's enhanced resistance characteristics are key to reducing machining costs and environmental impact in steel turning operations.

Keywords: cutting tools, steel, CVD, high-efficiency, dry cutting

1. Introduction

The main type of inserts used in cutting tools is a coated insert, in which hard ceramics are coated on the surface of a cemented carbide*1 base material. Coated inserts currently account for more than 70% of all insert grades. The workpiece materials that are machined with coated inserts are classified into six categories by ISO 513:2004: steel, stainless steel, cast iron, nonferrous metals, heat-resistant alloys, and hard materials, of which steel is the most common workpiece material.

In recent years, there has been an even greater demand than before for shorter machining times and dry cutting without the use of cutting fluid, which are expected to reduce power consumption from the standpoint of reducing environmental impact, as well as improve productivity through more efficient machining conditions. Both of these factors lead to a rising temperature in the cutting edge during cutting, and because tools are used in harsh environments, higher performance is required now than in the past.

In response to various steel turning needs, we have developed and produced the AC8000P series of coated grades that provide long tool life and stability in a wide range of cutting condition.(1) In this instance, as a new generation grade, we have developed and launched AC8115P, which achieves stable and long life in high-efficiency machining and dry cutting, especially in response to the need to reduce environmental impact. This report describes the aims, features, and cutting performance of AC8115P.

2. Issues in Steel Turning and Positioning of AC8115P

The required characteristics of inserts vary depending on the shape of the workpiece material and cutting conditions, so it is necessary to select a grade that matches the situation. In continuous cutting, where there are no interrupted parts such as holes or grooves on the surface, the cutting edge is in constant contact with the workpiece material, resulting in high temperatures due to frictional heat. Since the hardness of the tool material decreases at high temperatures, a grade with higher heat resistance and wear resistance should be selected for this situation. It is also significant in high-efficiency machining. One of the reasons cutting fluid is used is to control the temperature rise of the cutting edge, but since no cutting fluid is used in dry cutting, the temperature of cutting edge is also high.

AC8115P is a new grade with improved heat resistance and wear resistance that provides stable and longer tool life even in severe cutting condition such as high-efficiency machining and dry cutting. AC8115P can be adapted for high-speed cutting (Fig. 1).

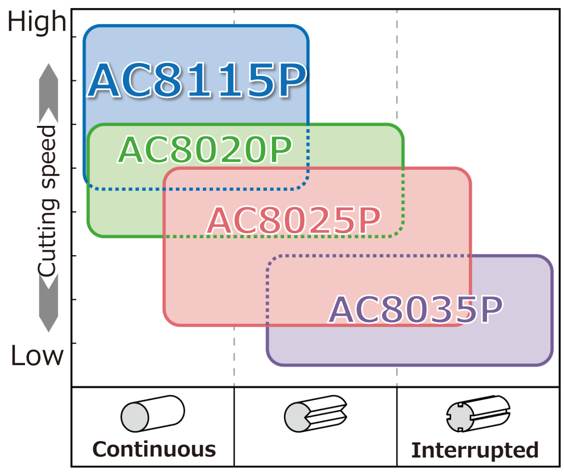


Fig. 1. Application range of AC8115P

3. Features and Cutting Performance of AC8115P

Our CVD*2 coating technology "Absotech," which is also applied to steel turning grades, has common specifications that include a multi-layer coating consisting of titanium carbon nitride (TiCN) and alumina (Al_2O_3) on cemented carbide, but the overall coating thickness is optimized according to the application. In addition, a used-identification layer is applied to the topmost surface of the coating to make it easier to determine whether the corner is used or not, and special surface treatments are applied according to the application as well as the coating composition. For AC8115P and AC8020P, which require higher wear resistance than conventional steel turning grades, the Al_2O_3 layer is applied, and the crystal orientation is aligned in the coating thickness direction, and the Al_2O_3 layer with controlled crystal orientation is applied to improve resistance to shear direction loading that occurs when chips rub against the tool surface.

AC8115P has three features, all of which improve wear resistance and contribute to longer life in high-efficiency machining and dry cutting. By improving the wear resistance of the used-identification layer, which did not contribute to the wear resistance in conventional grades, the initial wear is suppressed. Figure 2 shows the results of evaluating the wear resistance of AC8115P. The workpiece material was an alloy steel (SCM435) round bar, with cutting conditions set as follows: cutting speed (vc) is 270 m/min, feed rate per revolution (f) is 0.30 mm/rev, depth of cut (ap) is 1.5 mm, and the use of cutting fluid (wet). The AC8115P showed less flank wear than the competitor's grade, confirming its high wear resistance.

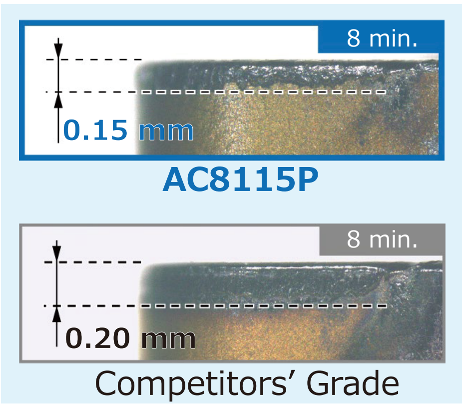


Fig. 2. Comparison of initial flank wear

The second is the improvement of wear resistance due to the improved orientation and finer-grain Al_2O_3 layer. Since Al_2O_3 is an oxide, it is not affected by embrittlement due to oxidation and plays a very important role under conditions where the cutting edge is exposed to high temperatures. As shown in Fig. 3, the crystal orientation-controlled fine Al_2O_3 layer applied to AC8115P further enhances the crystal orientation and grain refinement compared to the conventional crystal orientation-controlled Al_2O_3 layer, thereby increasing the overall strength and reducing wear due to crystal dropout.

This crystal orientation-controlled fine-grain Al_2O_3 layer is particularly effective in suppressing rake wear in high-efficiency machining and dry cutting.

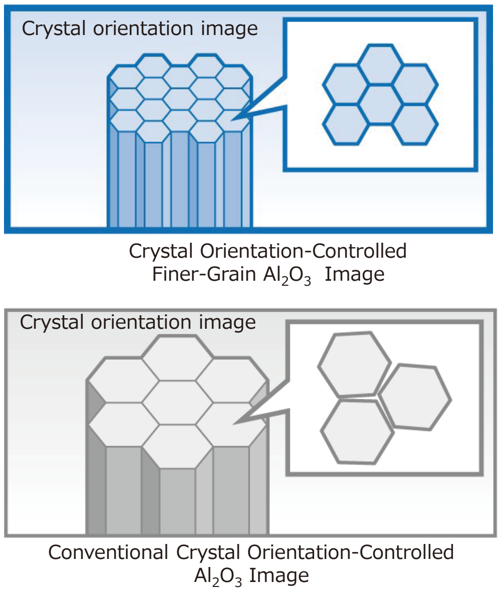


Fig. 3. Comparative image of Al_2O_3 layer

The third is to improve resistance to plastic deformation*3 by using cemented carbide with excellent high-temperature properties. The cemented carbide used in AC8115P has improved properties at high temperatures, suppressing plastic deformation, and in combination with the above-mentioned Al_2O_3 layer with fine crystalline orientation, it provides longer tool life even in machining where the cutting edge is at high temperatures. Figure 4 shows the results of evaluation of the wear resistance of the conventional grade and AC8115P as a correlation between

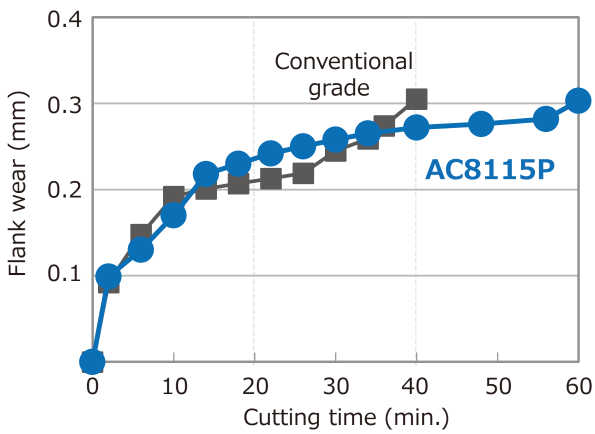


Fig. 4. Wear resistance of AC8115P

cutting time and the amount of flank wear. The workpiece material was a round bar of alloy steel (SCM435). Tests were conducted under the following cutting conditions: vc = 270 m/min, f = 0.30 mm/rev, ap = 1.5 mm, wet. As shown in Fig. 5, it was confirmed that the AC8115P exhibited high wear resistance while the conventional grade showed rapid flank wear due to plastic deformation of the cutting edges as the rake wear progressed.

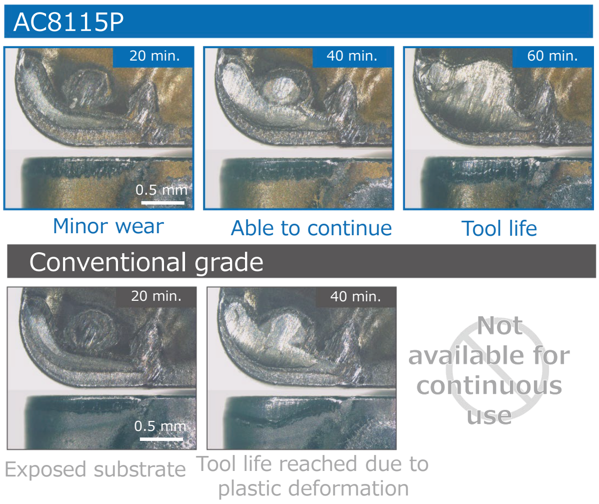


Fig. 5. Comparison of damage between AC8115P and the conventional grade

Figure 6 shows the change in the amount of flank wear versus cutting time for the AC8115P and the conventional grade when the cutting speed is increased to 350 m/min while the feed rate and depth of cut conditions remain the same for the above wear resistance test. When the cutting speed is 270 m/min, the tool life of AC8115P is 1.5 times longer than that of the conventional grade, but when the cutting speed is 350 m/min, the cutting time when the flank wear exceeds 0.3 mm is more than twice the difference, confirming that AC8115P has high wear resistance even under high cutting speed conditions.

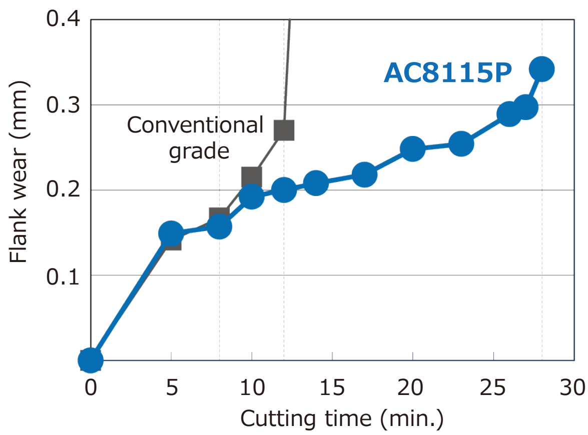


Fig. 6. Wear resistance of AC8115P at vc = 350 m/min

Figure 7 shows the damage to the cutting edges of the conventional grade and AC8115P at cutting times of 8, 12, and 28 minutes in the above wear resistance test. In the conventional grade, plastic deformation occurred at 12 minutes due to a decrease in cutting edge strength caused by the development of crater wear, and flank wear developed significantly. On the other hand, it was confirmed that the AC8115P showed only minor progress in crater wear.

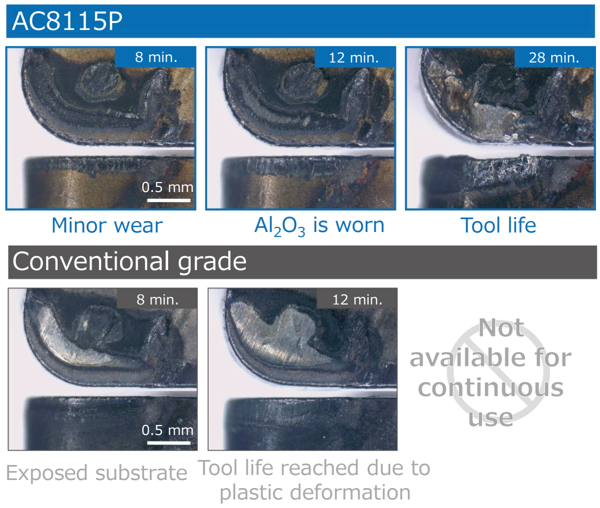


Fig. 7. Comparison of damage conditions at vc = 350 m/min

Figure 8 shows the effect of reduced power consumption due to shorter machining time in high-speed machining. The workpiece material was a round bar of alloy steel (SCM415), and the common cutting conditions were f = 0.30 m/rev, ap = 1.5 m, and wet. Cutting speeds were set at 300 m/min for conventional machining using conventional grade and 450 m/min for high-speed machining using AC8115P. Power consumption was measured from the time when the lathe started to operate until it stopped. Although the value of power during cutting increased in high-speed machining, the overall power consumption was reduced by about 25% compared to conventional machining due to the 40% shorter cutting

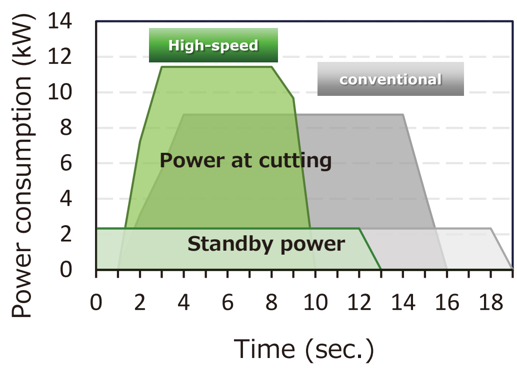


Fig. 8. Effects of reducing electricity consumption by shortening machining time with high-speed machining

time. Converting this power consumption using the national average emission coefficient by electric utility (0.000433 t-CO_2/kWh) published by the Ministry of Economy, Trade and Industry, 200 cycles of the above processing (cutting distance: about 20 km) will result in a reduction of approximately 0.9 kg of CO_2 emissions.

The results of the wear resistance test in dry cutting without using cutting fluid at the same cutting speed, feed rate, and depth of cut as the cutting conditions in the wear resistance test shown in Fig. 4 are shown in Fig. 9.

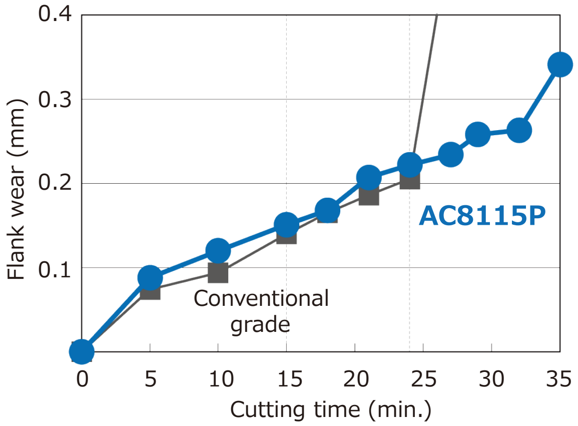


Fig. 9. Wear resistance of AC8115P in dry cutting

Figure 10 shows damage to the cutting edges of the conventional grade and AC8115P at 15, 24, and 35 minutes of cutting time in the above wear resistance test. In both cases, the cemented carbide exposed at the point where the coating was worn off was oxidized, resulting in a rainbow coloration on a section of the rake face. This suggests that the cutting-edge temperature became high during machining due to dry cutting. It was confirmed that AC8115P exhibited higher wear resistance than conventional grades even under such severe cutting conditions.

Fig. 10. Comparison of damage in dry cutting

Figure 11 shows an example of actual use. Example (a) is an automotive part called a rotor shaft, which is made of relatively hard steel, and the machining distance is long, so the temperature of the cutting edge easily rises. While the competitor's grade showed significant crater wear after machining 4 pieces, the AC8115P suppressed the crater wear, and even after machining 5 pieces, damage was minimal, resulting in a 25% improvement in tool life. As in case (a), the machining in case (b) is of a rotor shaft with a higher cutting speed of vc = 310-340 m/min and the cutting-edge temperature tends to rise. In this machining process, the competitor's grade showed significant progress not only in crater wear but also in flank wear, suggesting that plastic deformation occurred. Even in such a severe machining environment, the AC8115P suppressed wear and plastic deformation, enabling the machining of 150 pieces, compared to 120 pieces for the competitor's grade, resulting in a 25% improvement in tool life. Case (c) is an example of a transmission part where the cutting speed is high and the depth of cut is relatively small, so the flank wear tends to increase. The AC8115P significantly suppressed the progress of flank wear. As a result, while the competitor's grade reached the end of its tool life after machining 80 pieces, the AC8115P was able to machine 100 pieces with only minor damage to the cutting edge, resulting in a 25% improvement in tool life.

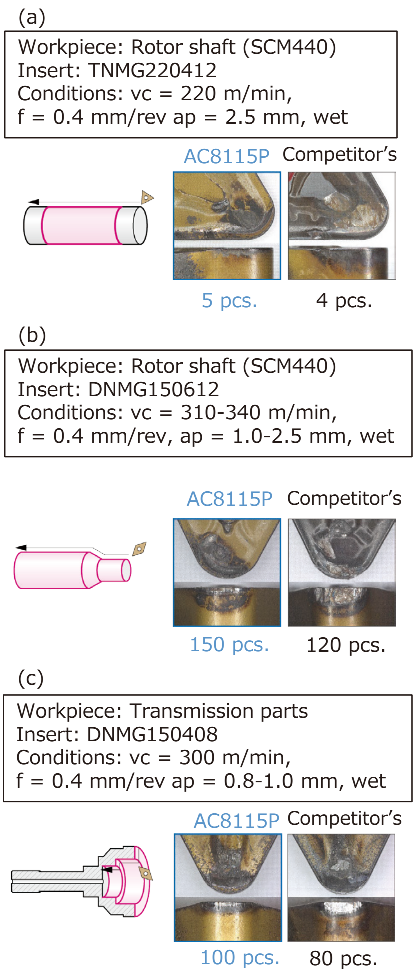


Fig. 11. Actual cases of AC8115P in customers

4. Conclusion

AC8115P has improved wear resistance of the used-identification layer, Al_2O_3 layer orientation strengthening and refinement, and improved plastic deformation resistance of cemented carbide, enabling longer service life in high-efficiency machining and dry cutting. We believe that AC8115P will significantly contribute to reducing machining costs and environmental impact reduction in steel turning.

Technical Terms

∗1 Cemented carbide: A composite material of ceramics and metal, consisting mainly of tungsten carbide (WC) and cobalt (Co).

∗2 CVD: Chemical Vapor Deposition: A method of applying a ceramic coating to a substrate surface using a chemical reaction.

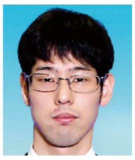
∗3 Plastic deformation: A deformation that occurs when an external force is applied to an object and then remains after the external force is removed.

Reference

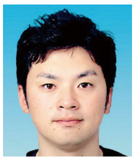
(1) T. Yamanishi et al, "New Coated-Carbide Grade AC8020P for Steel Turning," SUMITOMO ELECTRIC TECHNICAL REVIEW, No. 93, pp. 50-53 (2021)

Contributors The lead author is indicated by an asterisk (∗).

M. HIKIJI*
• Sumitomo Electric Hardmetal Corp.



A. YONEDA
• Assistant Manager, Sumitomo Electric Hardmetal Corp.



T. YAMANISHI
• Assistant Manager, Sumitomo Electric Hardmetal Corp.

H. KANAOKA
• Manager, Sumitomo Electric Hardmetal Corp.