Development of New Coated Carbide Grade "ACE COAT AC810P" for Steel Turning

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Sumitomo Electric Hardmetal Corporation has newly developed a coated carbide grade "ACE COAT AC810P." AC810P is a grade used exclusively for high speed steel turning, featuring more than 1.5 times higher wear resistance than that of our conventional model "AC700G." AC810P has successfully achieved this property using our original chemical vapor deposition (CVD) coating technology "Super FF Coat." This coat consists of a titanium carbonitride film with a fine, smooth surface and an alumina film with a cemented carbide substrate. AC810P also realizes higher resistance to crater wear by applying a reinforced thick alumina coating. Recently, the authors have also developed a highly efficient chip breaker "ME-type" for roughing, applying similar designing concepts as previously developed "SE-type" and "GE-type." Combination use of ACE COAT AC810P and either SE-type, GE-type or ME-type chip breaker remarkably improves tool life and machining efficiency. With our coated carbide series, consisting of the three steel turning grades: "AC810P" for high speed and continuous machining, "AC820P" for general machining, and "AC830P" for interrupted machining, Sumitomo Electric Hardmetal Corporation meets expectations from customers who wish to save on machining costs and improve productivity.

Keywords: steel turning, CVD, TiCN, Al_2O_3

1. Introduction

A coated grade is a tooling insert made up of ceramic coating on cemented carbide substrate. It is widely used for steel turning because of the high wear resistance and toughness compared with other inserts. The coated grade accounts for 70% of all inserts currently in use (**Fig. 1**).

The coated grade is used to process various work materials, such as carbon steel, alloyed steel, stainless steel and cast iron, into components and parts for the automobile, machine, steel, railroad, and power generation industries.

In recent years the awareness of improving productivity and cutting down on tool cost has increased among cutting tool markets. We have previously marketed CVD (chemical vapor deposition)-coated grade "ACE COAT AC820P" and "ACE COAT AC830P" featuring long tool life and improved work efficiency.

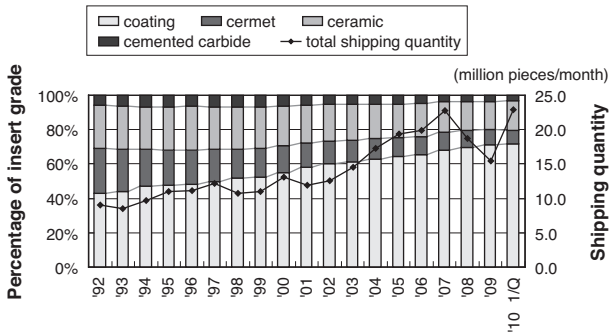

Fig. 1. Proportion of each indexable insert grade in total shipping quantity (Japan)[1]

In the view of environmental protection, however, further improvement in machining process — power saving and dry cutting with no coolant — has been expected. Accordingly, advanced grades that can ensure stable cutting and sufficient tool life even under these stringent processing conditions are in demand. In response to this demand, we have launched "ACE COAT AC810P," which features even higher wear resistance than that of our conventional model "AC700G." The development background and characteristics of the new grades are reported below.

2. Development Goals and New Technologies of AC810P

Figure 2 shows a grade map of our steel turning products. The coated carbide "AC800P" product series cover a broad range of applications from high speed to interrupted cutting for steel turning. "AC810P" has high wear resistance and is suitable for high speed and continuous machining. "AC820P" widely covers continuous machining and interrupted machining, and thus, is used for general purposes. "AC830P" has high strength and fracture resistance, and therefore, is suitable for heavy and interrupted machining.

Current trend of CVD products is to apply surface treatment after CVD deposition in order to improve their performances. However, this treatment makes the appearance dark, bringing difficulty to distinguish whether the cutting edge is used or not. For example, an insert is thrown away after three corners are used, even though it can be used with four corners.

"AC800P" product series adopts special surface treat-

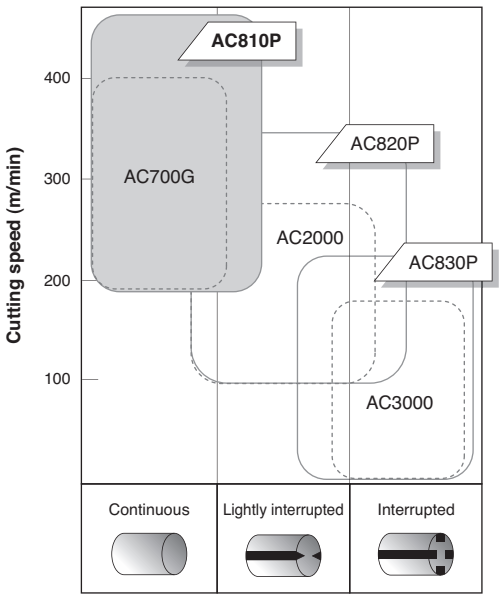

Fig. 2. Application domains of AC810P, AC820P and AC830P

ment and they have gold appearance, avoiding the problem mentioned above.

2-1 Development goals of AC810P

In order to clarify the development goals of our new grade for high speed steel turning, we collected data of "AC700G" from our customers. As the result of investigating cutting edges of their used insert, we came to the conclusions that more than 50 % of damage to the grade was crater wear. As shown in **photo 1**, crater wear is mainly caused by chip flow on rake face during machining. Extension of crater wear leads to worse chip control and sometimes breakage since the toughness at the cutting edge is reduced. Also, friction heat leads increase in cutting temperature since chip contacts constantly on rake face for continuous steel turning. In general, crater wear tends to spread as the cutting speed increase, since hardness of both carbide substrate and ceramic coating decrease with increase in temperature. This tends to be prominent in high efficiency and dry cutting.

As alumina is chemically stable and has a low affinity for work materials and high thermal insulating properties,

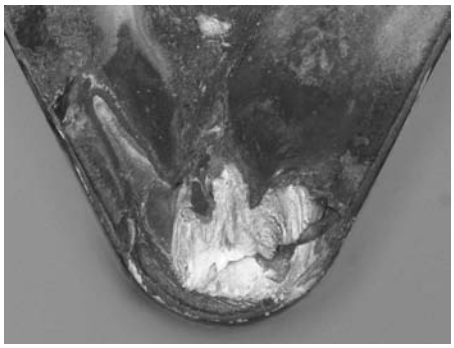

Photo 1. An example of crater wear

it is clear that thickening the alumina coating can improve crater wear resistance. Our conventional grade "AC700G" shows good wear resistance from low to middle cutting speed, while tends to show low tool life due to heavy crater wear for high speed cutting since the alumina coating is thin. Accordingly, we set the highest priority for developing new grades on the reduction of damages caused by crater wear. For the in-demand field of high efficiency machining and dry cutting, we set our development target of 1.5 times higher resistance against crater wear compared with conventional grades.

2-2 Development of AC810P

Figure 3 shows a comparison of cross-sectional SEM images of a conventional grade and AC810P. AC810P is composed of our original CVD coating "Super FF-TiCN" and newly developed toughened thick alumina.

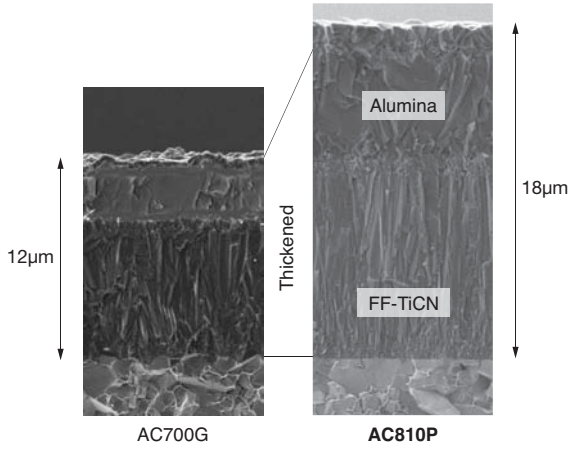

Fig. 3. Cross sectional SEM images of AC810P and conventional grade AC700G

Merely thickening conventional alumina coating isn't a fundamental solution for the damage. Our careful study with advanced experimental equipment indicated that the alumina coating was not worn out but cracked, and therefore that improving the toughness of the alumina coating was the top priority. We increased alumina grain size to prevent cracks from spreading in the coating (**Fig. 4**). By thickening this newly developed alumina coating, we have succeeded in increasing crater wear resistance dramatically.

Other feature of AC810P is that this product adopts "Super FF-TiCN," which is also applied in AC820P and AC830P. Super FF-TiCN coating technology offers significantly small grain with dense and homogeneous structures (**Fig. 5**). By thickening Super FF-TiCN, AC810P yields a high coating strength, resulting in high resistance against peeling of coating, chipping and wear.

Figure 6 shows V-T diagram of AC810P, our conventional grade AC700G and a competitor's P10 grade. AC810P shows 1.5 times longer tool life — the flank wear reaches 0.20 mm — and also achieves high wear resistance even when the cutting speed exceeds V = 300 m/min. As can be seen in this figure, it is possible to increase cutting

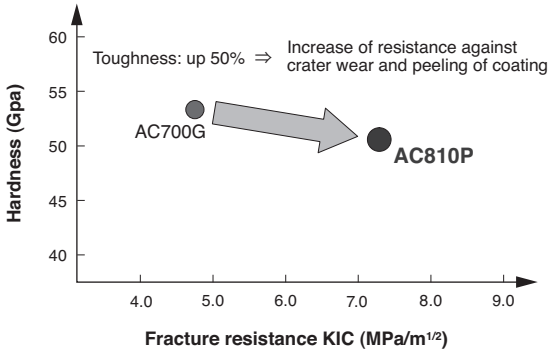

Fig. 4. Physical properties of newly developed alumina

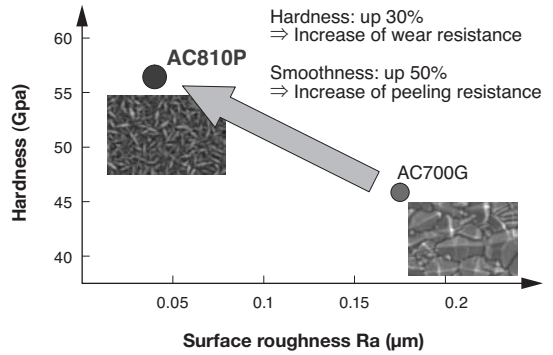

Fig. 5. Physical properties of Super FF-TiCN

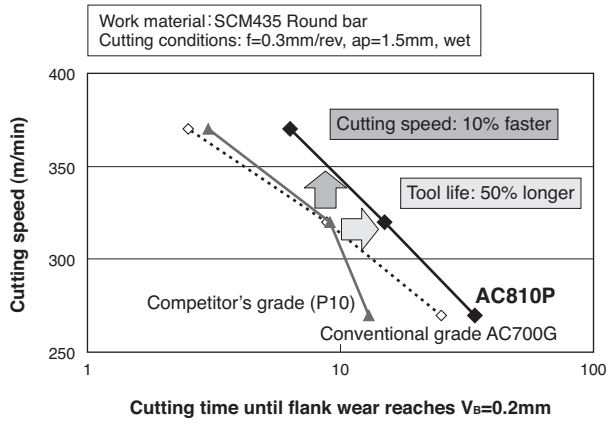

Fig. 6. Evaluation results on wear resistance under high speed machining

speed more than 10% by using AC810P.

Another development target clarified by the analysis of worn AC700G grades is to improve chipping resistance. It was revealed that chipping and peeling of the coating occurred at the cutting edge. AC810P adopts a thick coating to increase wear resistance and a special surface treatment to enhance chipping resistance. To achieve higher chipping resistance, while coping with the trade-off between wear resistance and chipping resistance, we optimized the thickness of the alumina coating at the cutting edge. **Figure 7** indicates that AC810P shows more than 1.5 times higher chipping resistance than the competitor's P10 grade.

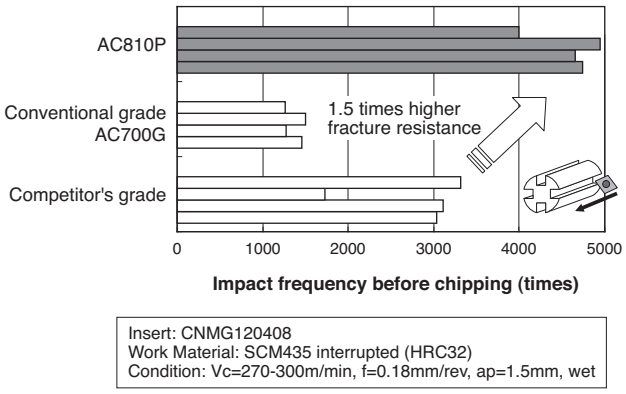

Fig. 7. Evaluation results on fracture resistance under interrupted cutting

3. Development of ME-type Chip Breaker for Roughing

As mentioned above, it is very important to increase crater wear resistance for high-efficiency machining. However, crater wear is affected not only by grades but also by

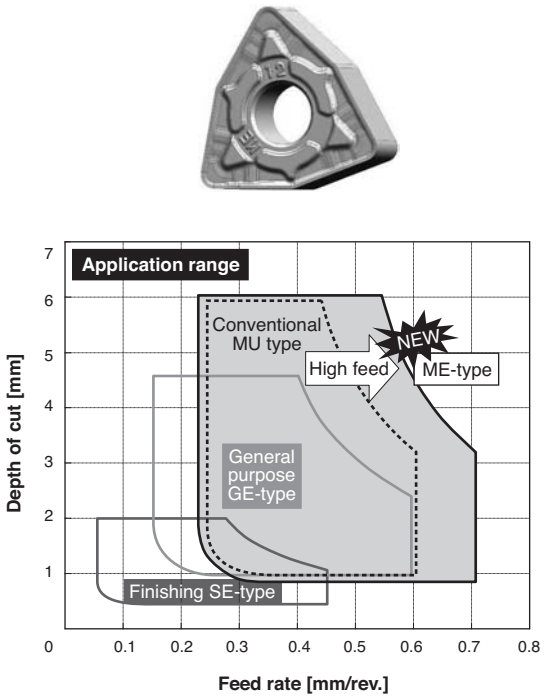

Fig. 8. Design and application range of newly developed ME-type for rough machining

chip breaker geometry. We have previously marketed GE-type and SE-type featuring improved work efficiency.

Along with the development of the grade, we have also developed an ME-style chip breaker, which features even higher work efficiency for roughing.

In the development of GE-type and SE-type, we have found that crater wear is more effectively avoided with the stress spread across the chip breaker at a smaller hitting angle rather than with the stress sharply centered on a point. Consequently, we have applied this principle to ME-type to reduce crater wear and realized better performance in high efficiency cutting processing such as high feed and large depth of cut.

With ME-type added to our chip breaker lineup of "E series," we will meet a wide range of requirements from various customers who wish to improve their productivity.

4. Cutting Performance with AC810P

Drawing on the reinforcement technology and the alumina coating doubled in thickness, AC810P exhibits high resistance to crater wear. As shown in **Fig. 9**, crater wear of AC810P is negligible with the cutting edge undamaged even after intensive machining. Furthermore, tool life increases by 40% compared to the competitor's P10 grade. **Figure 10** shows the comparison of cutting edges between AC810P and a competitor's P05 product after dry cutting at 400 m/min. AC810P shows smaller crater wear and 40% longer tool life than the P05 grade, which has higher wear resistance than a P10 grade. **Figure 11** is an example of AC810P application used in combination with an ME-type

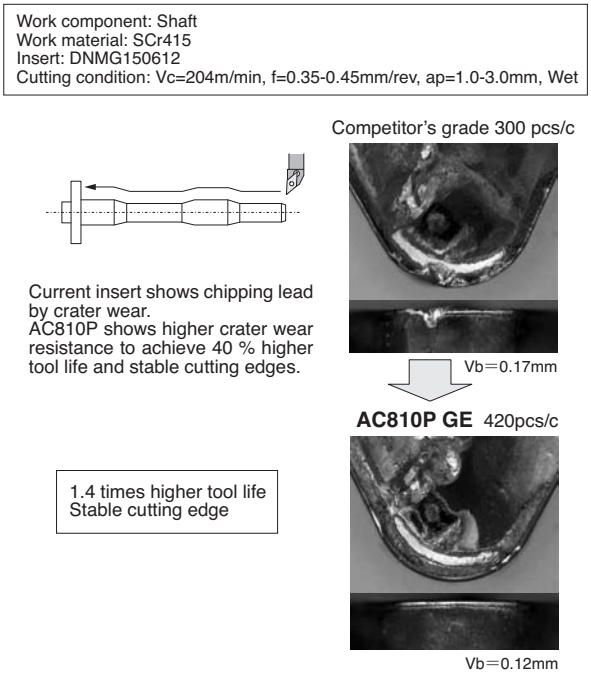

Fig. 9. Trial experiment of AC810P for high feed machining

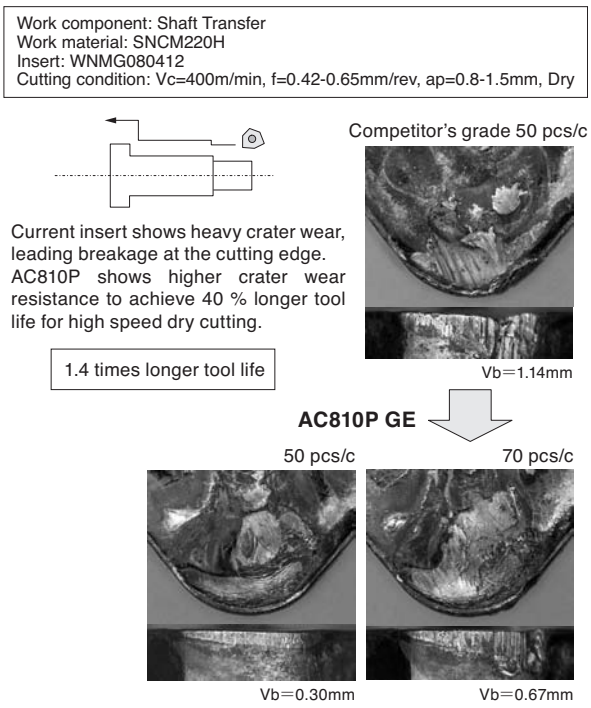

Fig. 10. Trial experiment of AC810P for high speed and dry cutting

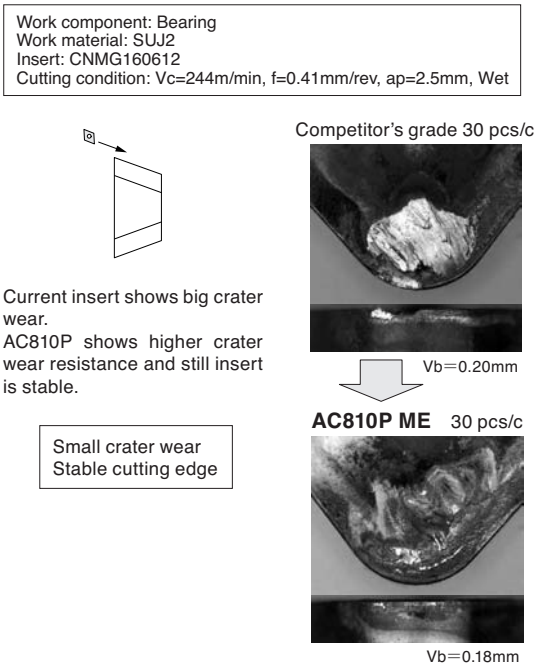

Fig. 11. Trial experiment of the combination of AC810P and ME-type

breaker. Compared to the competitor's P10 grade, AC810P exhibits better crater wear resistance after roughing at 0.4mm/rev, making its long-term use possible.

5. Conclusions

ACE COAT AC810P, used in combination with SE-type, GE-type or ME-type chip breaker, ensures long service life and increased cutting efficiency in high speed and continuous machining. The development of AC810P has enhanced our product lineup to cover a broad range of applications from high speed to interrupted machining. We believe that this series of products will meet various requirements from customers in terms of work efficiency and machining costs.

* ACE COAT and SUPER FF COAT are trademarks or registered trademarks of Sumitomo Electric Industries, Ltd.

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