Ultra-Thin High-Precision Cutters Made of Cemented Carbide

1. Overview

Ultra-thin high-precision cutters made of cemented carbide (cemented carbide cutting blades) possess high hardness and excellent wear and corrosion resistance. They are used for precision cutting of pre-fired ceramic materials, films, foils, fibers, and similar items. A.L.M.T. Corp. has established an integrated production system covering the processes from carbide manufacturing to final tip shaping. We manufacture ultra-thin cutting blades down to a minimum thickness of 0.05 mm to meet customer requirements. We also offer specification design (tip angle, tip shape, etc.) tailored to the cutting material and perform cutting evaluations. We propose and provide the optimal cutting blade for each application, considering factors like sharpness and durability. This article introduces the features and cutting performance of these cemented carbide cutting blades.

2. Features

2-1 Cemented carbide

Cemented carbide is primarily a composite material consisting of tungsten carbide (WC) as the hard phase and cobalt (Co) as the binder phase (Fig. 1).

Cemented carbide is widely used as a material for cutting tools and wear-resistant parts due to its excellent balance of properties: higher hardness than high-speed steel and higher toughness than ceramics.

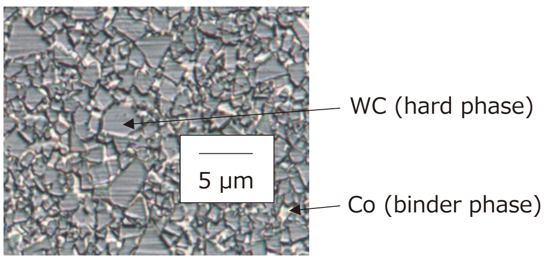


Fig. 1. Microstructure photograph of cemented carbide

2-2 Cemented carbide cutting blades

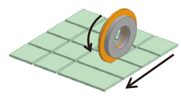
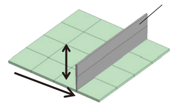
(1) Advantages of press-cutting

Conventionally, precision cutting has primarily employed the dicing method, which involves high-speed rotation of a dicing blade (a circular rotating diamond blade) while cutting with cooling and flushing of chips using a processing fluid. While this method excels in vertical cutting and ensuring dimensional accuracy, it has several drawbacks: the circular blade results in longer cutting times; the use of the processing fluid requires three processes (cutting, washing, and drying), occupying significant equipment space on the production floor; and kerf loss occurs due to the thickness of the circular blade.

In contrast, cutting using cemented carbide cutting blades employs a press-cutting method, where the cut is made instantaneously. Furthermore, as it is a dry cutting process requiring no cutting fluid, it eliminates the need for post-cutting cleaning and drying steps. Consequently, it achieves highly space-saving and effective cutting compared to the dicing method. Additionally, the extremely sharp cutting edge allows for press-cutting, eliminating the need for a cutting allowance. This significantly increases the number of chips obtainable from a single sheet, offering significant advantages in material yield (Table 1).

Furthermore, from a reuse perspective, our company collects worn cemented carbide cutting blades used by customers, regrinds the cutting edges, and resells them to customers with quality equivalent to new blades.

Table 1. Comparison of dicing method and press-cutting method

	Dicing		Press-cutting	
Method	Wet 		Dry 	
Quality	Excellent vertical cutting performance and good dimensional accuracy of products	good	Sharp cutting edges ensure product dimensional accuracy	good
Productivity	• Cutting speed: Low • Cleaning and drying processes required • Cutting allowance required	bad	• Cutting speed: High • No cleaning or drying required • No cutting allowance	Excellent

(2) Ultra-thin long substrates

Our cemented carbide cutting blades are manufactured by sizing and sharpening long plates to produce products tailored to customer requirements (Fig. 2).

T (mm)	0.05～
H (mm)	18～
L (mm)	30～400
θ (°)	10～90

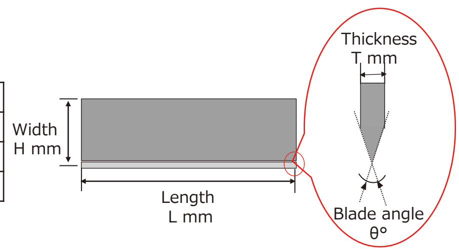


Fig. 2. Cemented carbide cutting blade dimensions overview

The substrate thickness of our cemented carbide cutting blades are minimized to 0.05 mm through our ultra-precision grinding technology. This enables the cutting edge length to be shorter compared to thicker substrates during edge-sharpening processes. Consequently, it reduces protrusion during customer use and minimizes cutting edge deflection, leading to improved cross-sectional accuracy of the workpiece (Fig. 3).

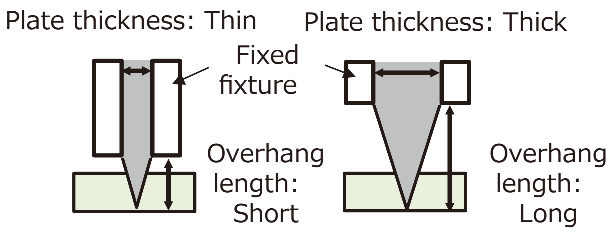


Fig. 3. Advantages of ultra-thin long substrates

2-3 Customer requirements and desired characteristics for cemented carbide cutting blades

Customers have the following three requirements for press-cutting operations: 1) Improved vertical cutting performance, 2) Enhanced cut surface quality, and 3) Extended tool life. To address these: 1) For improved vertical cutting performance, a specification for a sharp cutting edge with a thin blade thickness and low cutting resistance is required; 2) For improved cut surface quality, a sharp cutting edge is required. Furthermore, as nicks on the cutting edge can cause damage to the cut surface, a cutting edge specification with resistance to chipping is required; and 3) For extended tool life, a cutting edge specification that possesses chipping resistance and maintains stable cutting performance is necessary. In other words, the requirement for a "sharp cutting edge with chipping resistance" poses a design trade-off challenge. The key to achieving this lies in how well these two aspects can be balanced.

(1) Development of a sharp cutting edge with damage resistance

The cemented carbide edge features a uniform and durable sharp cutting edge along the cutting length. The cutting edge angle can be formed from 10° to 90°, and the very tip can be shaped to as small as 0.5 µm, which is equivalent to the size of a single WC particle (Fig. 4).

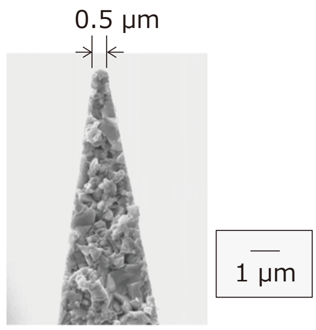


Fig. 4. SEM image of the cutting edge's very tip

Our company utilizes unique processing methods and specialized fixtures to achieve high-precision and sharp cutting edge forming. The newly developed blade utilizes a finer-grained material compared to conventional edges to achieve a sharper cutting edge. While the formed cutting edge is sharp and prone to chipping, this issue is addressed with a special edge treatment that produces a curved, mirror-like surface (Table 2).

Table 2. Comparison of conventional and developed cutting edges

	Size of hard phase particle	Shape of cutting edge	Tip grinding mark
Conventional blade	0.5 µm	Straight	Rough surface
Developed blade	0.3 µm	Curved	Mirror surface

(2) Cutting performance evaluation of the developed blade

Our company has established a system for conducting cutting evaluations. Below is an example of a cutting evaluation for a blade developed in response to the customer requirements mentioned above. The material to be cut was selected as polyvinyl chloride (PVC) due to its uniform composition and hardness, and its easy availability. The evaluation apparatus used a high-precision machining center. A carbide blade was mounted on the spindle using a dedicated cutter holder. Continuous cutting was performed while locking the spindle. To avoid cutting the same location on the PVC repeatedly, step movements were used to implement press-cutting operations (Fig. 5).

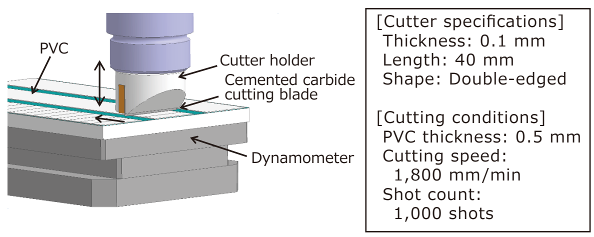
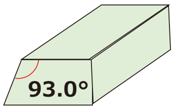
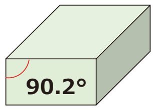


Fig. 5. Cutting test image

High-speed camera analysis of the cutting process showed that the developed blade's sharp cutting edge enabled vertical cutting. The post-cut workpiece surface angle was 93.0° for the conventional blade versus 90.2° for the developed blade. Surface roughness was significantly reduced: Sa: 0.19 µm for the conventional blade versus Sa: 0.02 µm for the developed blade, approximately one-tenth the value, confirming improved surface finish quality. Regarding chip resistance, which was a trade-off for sharpness, no chipping was observed on the developed blade due to its special tip treatment (Table 3).

Thus, we have developed cemented carbide cutting blades that enable high-quality cutting without chipping, even when subjected to large forces at the sharp cutting edge.

Table 3. Summary of developed blade evaluation results and developed cutting edges

	1) Vertical cutting	2) Quality of cut surface	3) Long life
	Cut surface angle of workpiece (°)	Surface roughness Sa (μm)	Presence / absence of tip chipping after 1,000 shots
Conventional blade		0.19	Presence
Developed blade		0.02	Absence

3. Conclusion

While press-cutting with cemented carbide cutting blades has traditionally faced challenges attributable to their short tool life due to extreme sharpness, we have successfully developed cemented carbide cutting blades that maintain sharpness and demonstrate superior damage resistance through specialized edge treatment. Leveraging our strength as a member of the Sumitomo Electric Group with an integrated manufacturing system from raw materials to finished products, we aim to expand the use of this product in various fields, including all-solid-state batteries and automotive applications whose demand is anticipated to grow.