Development of SEC-Dual Mill DGC Series for General-Purpose Face Milling

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General-purpose face milling cutters are widely used in metal machining. These tools are required to reduce machining cost and offer a wide range of applications. Furthermore, they need to ensure excellent surface finish for highly functional parts. To address these challenges, Sumitomo Electric Hardmetal Corporation has developed a new milling cutter "SEC-Dual Mill DGC" series for general-purpose face milling. This series employs negative inserts which can be used on both sides to enable cost effective machining. Moreover, the cutter body can use both square inserts with 8 cutting edges and octagonal inserts with 16 cutting edges. A variety of breakers, including burr-reducing breakers, are also available to provide a broad range of applications.

Keywords: steel, milling, general-purpose

1. Introduction

Face milling cutters are the most commonly used tools in metal machining. They are required to reduce the machining cost and to be adaptable to a wide range of applications. To reduce the machining cost, inserts with multiple cutting edges are required to streamline the machining process and minimize the tool cost. It is considered that face milling cutters are used with various shapes and materials of insert and chip breaker to carry out a wide range of tasks. Moreover, a high-quality machined surface is required for the improved performance of components in recent products, increasing the demand for cutting with improved surface quality.

To meet the above requirements, we have developed a new series of face-milling cutters, the SEC-Dual Mill DGC series (**Photo 1**), with indexable inserts using our newly developed coating technology. The DGC series can produce high-quality machined surfaces, has high versatility, and is cost-efficient through the use of negative inserts with double cutting edges. The features and cutting performance of the DGC series are described in this paper.

Photo 1. SEC-Dual Mill DGC series

2. Features of DGC Series

2-1 High cost-effectiveness

The inserts used for milling cutters are divided into two types: negative inserts, for which both sides are used for cutting, and positive inserts, where one side is used. Positive inserts can ensure the high performance of cutting edges, whereas negative inserts have a drawback of high cutting resistance. This difference is due to the different shapes of positive and negative inserts. Negative inserts are more significantly affected by the specifications of cutting edges than positive inserts because both sides of negative inserts are used for cutting. Because of this, negative inserts, which are less sharp than positive inserts, have seldom been used for general-purpose face milling, which requires particularly high cutting performance. However, the number of cutting edges of negative inserts can be efficiently increased because both sides of negative inserts can be used for cutting, which leads to increased cost-effectiveness. Moreover, negative inserts are less damaged than positive inserts because of the high strength of the cutting edges. As discussed above, positive and negative inserts have different features and should be appropriately used for different machining processes. In the developed DGC series, M-class negative inserts have been adopted to increase the number of effective cutting edges and thereby the cost-effectiveness of the tools. Chip breakers with a newly designed shape have also been adopted to obtain negative inserts with higher sharpness than those of our competitors, resulting in machining with as low a cutting resistance as that for positive inserts. Moreover, two different inserts, i.e., a square insert with eight cutting edges and an octagonal insert with 16 cutting edges, can be applied to the body of each cutter in the DGC series to satisfy a wide application range (**Figs. 1 and 2**). The maximum depths of cut for the square and octagonal inserts are 6.0 and 3.0 mm, respectively. All the cutting edges can be used for milling up to the maximum depth of cut. The cutting edges of negative inserts with a complicated chip breaker shape, similar to those used in the DGC series, are distorted during sintering if they are produced using conventional manufacturing technology, which generates a difference between the diameter of the inscribed circle on the front surface and that on the back surface. This deteriorates the runout of the edges when the insert is installed into the body of a cutter and results in a short lifetime of the insert. However, in the DGC series, the difference between the diameters of the inscribed circles is reduced to about half that of competitors' products by employing a newly developed high-accuracy molding technology.

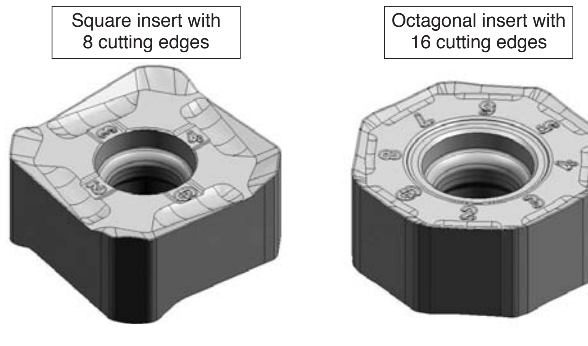


Fig. 1. Shape of chip breakers of inserts for DGC series

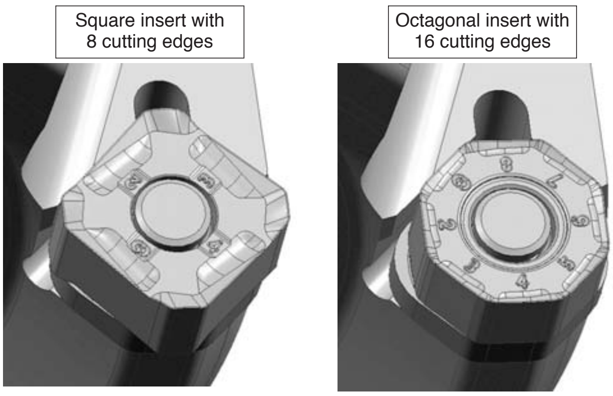


Fig. 2. Installation of inserts for DGC series

2-2 Roughing and finishing with improved efficiency

For the DGC series, a nonzero but very small face angle (FA) may be generated in the direction of rotation by the inappropriate tightening of screws when an insert is installed into the body of a cutter, similar to in our conventional tools (**Fig. 3**). Even a very small FA can be a major cause of the reduced quality of machined surfaces because most conventional tools have a linear wiper edge. To overcome this problem, we have developed an arc wiper edge and chip breaker each with newly designed shapes for negative inserts used with the DGC series to realize extremely sharp cutting edges and high-quality machined surfaces while maintaining the high strength of the cutting edges, one of the advantages of negative inserts (**Fig. 4**). When the shape of the wiper edge transferred onto a work material is an arc, as in the DGC series, the height of the joint step, which affects the quality of the surface being machined, decreases even when the insert has a nonzero FA. This is different from the case of linear wiper edges and enables surfaces to be machined with higher quality than that obtained using conventional tools (**Fig. 5**).

Thus, the DGC series is capable of producing high-quality surfaces, which have generally been obtained by fin-

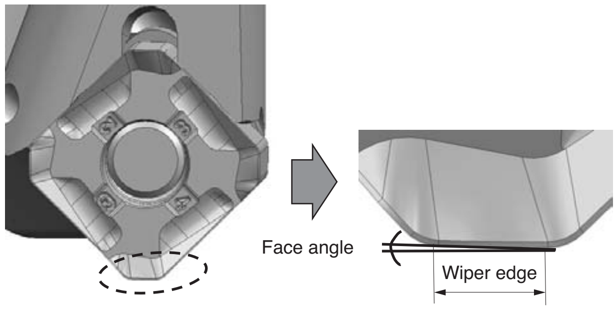


Fig. 3. Face angle

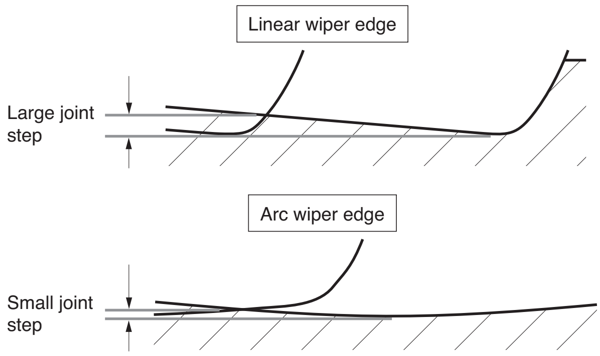


Fig. 4. linear and arc wiper edges

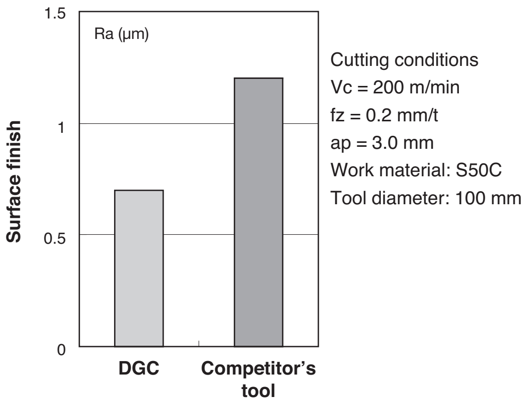


Fig. 5. Quality of machined surface

ishing, while maintaining high strength and sharpness of the edges, which is required for roughing. Hence, the DGC series can be used in machining from roughing to finishing without exchanging inserts, removing the step of exchanging tools and increasing the machining efficiency.

2-3 Wide chip breaker options

Various types of chip breaker have been prepared for the cutters of the DGC series to be used in a wide range of machining tasks as follows. For the square insert, a burr-reducing chip breaker has been prepared in addition to three types of chip breaker (**Fig. 6**): a G-type chip breaker as the main chip breaker with high versatility, an L-type chip breaker for light-duty cutting and low-rigidity machining, and an H-type chip breaker with stronger cutting edges for heavy-duty cutting. The octagonal insert also has G- and L-type chip breakers.

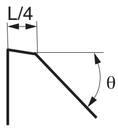
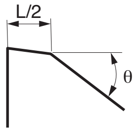
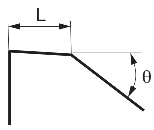
	L-type chip breaker	G-type chip breaker	H-type chip breaker
Shape of cutting edge			
θ	30˚	25˚	25˚
Uses	・Light-duty cutting ・Low-rigidity machining	・Main ship breaker ・General-purpose cutting	・Heavy-duty cutting ・Welded surface

Fig. 6. Chip breakers

Hard burrs may be generated from the end of a work material during face milling. When such burrs are generated, a process to remove them must be added, resulting in an increased machining cost. Therefore, chip breakers that can suppress the generation of burrs have been strongly requested from our customers. Although burrs are generated regardless of whether the insert is positive or negative, negative inserts generate harder burrs than positive inserts because of their sharper cutting edges. Therefore, a chip breaker that focuses on the reduction of burrs has been developed for the DGC series (**Fig. 7**).

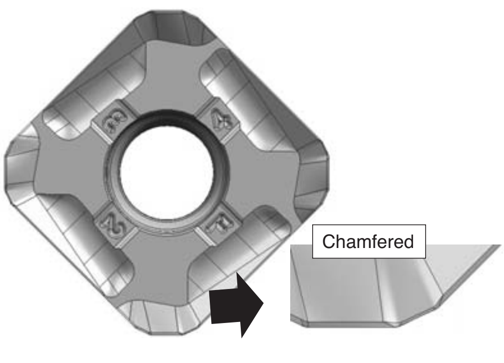


Fig. 7. Shape of burr-reducing chip breaker

Although most conventional tools employ a round (nose R) joint between the main cutting edge and the wiper edge of an insert (**Fig. 8**), this region is chamfered in the newly developed burr-reducing chip breaker (**Fig. 9**). This results in thinner metal chips on the side in contact with the work material and enables the metal chips to be smoothly removed from the work material, suppressing the generation of burrs.

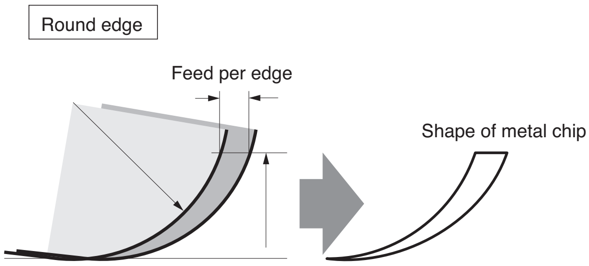


Fig. 8. Shape of metal chip for chip breaker with round edge

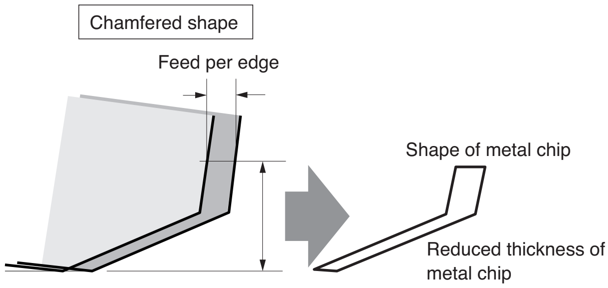


Fig. 9. Shape of metal chip for chamfered chip breaker

3. Evaluation by Customers

Examples of use of the DGC series by our customers are given below.

Example a) is the cube milling of a die material. When the DGC series is used, the cutting resistance is lower than that when a conventional tool is used, and a fivefold longer tool life is achieved when an appropriate combination of the insert and chip breaker is used (**Fig. 10**).

The application shown in Example b) has a large machining area and the problem of a variable machining allowance. This is satisfactorily solved by using the DGC series, which has a maximum depth of cut of 6 mm. The tool life using the DGC series is 1.4-fold longer than that using a conventional tool when an appropriate combination of the insert and chip breaker is used (**Fig. 11**).

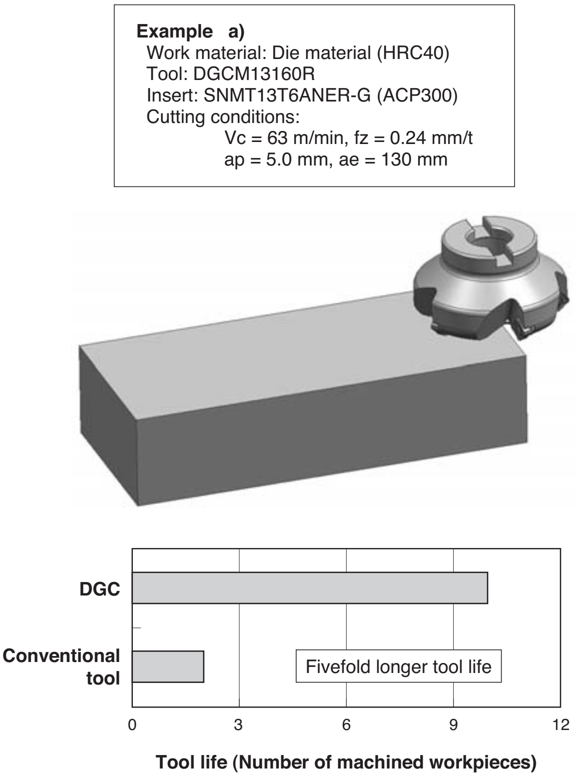


Fig. 10. Example a)

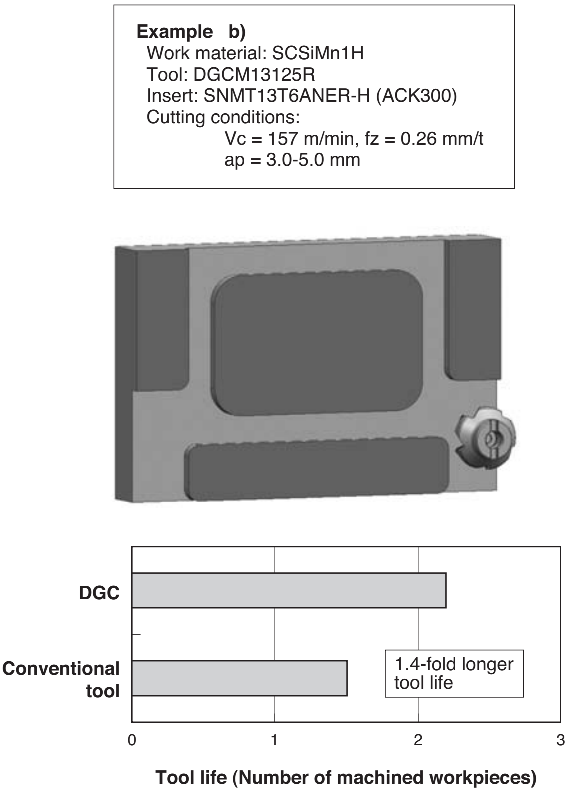


Fig. 11. Example b)

4. Conclusion

The SEC-Dual Mill DGC series are highly cost-effective milling cutters that can meet a wide range of market requirements and enable high-performance machining. We believe that the DGC series will contribute to reducing the cost of tools and improving the productivity of customers.

· SEC-Dual Mill is a trademark of Sumitomo Electric Industries, Ltd.

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