Milling

Barrel Cutter Shapes a New Milling Trend

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End mills featuring a cutting edge that is actually the segment of a large-diameter arc were introduced approximately 25 years ago. As the cutting-edge shape of these end mills is reminiscent of a barrel profile, terms such as "barrel milling cutters," "barrel end mills," or, in shop talk, often simply "barrels" soon became common when referring to these types of end mills. At first, the use of these barrel-shape mills was limited more or less to a few specific applications, such as machining 3D surfaces of complex dies and turbomachinery components. However, advances in 5-axis machining and in CAM systems have significantly expanded the boundaries of barrel end mill applications.

At the same time, the design principle of a cutting edge as the segment of a large-diameter arc has been realized successfully in other types of milling cutters – the tools for high feed milling (HFM), also referred to as "fast feed" (FF) milling. The concept provides a toroidal cutting geometry that ensures productive rough machining at extremely high feed rates due to a chip-thinning effect. Unlike high feed milling tools, barrel end mills are intended not for roughing but for finish and semi-finish machining of 3D surfaces with low stock removal.

Traditionally, ball-nose and toroidal cutters perform these machining operations. However, the large-diameter arc of the end mill cutting edge results in a substantial reduction of the cusp height generated between passes machined by a ball-nose or toroidal cutter. Another advantage of this type of cutting edge versus ball-nose and toroidal cutters is a significant increase in the distance between passes (a stepover or a stepdown, depending on the direction of a cutter displacement after every pass) – at least five times more without degradation of the surface finish parameters (Fig. 1). This means that the number of passes and, subsequently, machining time can be noticeably reduced. Increasing the distance between passes also improves tool life and, therefore, diminishes tool cost per part.

(Fig. 1) Barrel cutters offer a significant increase in the distance between passes, at least five times more without degradation of the surface finish parameters.

The classical barrel shape in end mills has undergone some changes to make these cutters more versatile. Combining a ball-nose tip with peripheral large-arc cutting edges creates a multi-purpose "cutting oval," which facilitates the use of a barrel end mill as a ball-nose milling tool. In taper end mills, transforming the profile of a major cutting edge into a large-arc segment generates another cutting oval – a taper barrel. When compared with a common taper end mill, the taper barrel provides theoretically pinpoint contact between the major cutting edge and a machined surface that decreases accuracy errors and prevents recutting of a produced shape. The taper shape also contributes to reducing tool overhang – an important factor for improving tool performance. Barrel and oval end mills are mainly utilized for cutting side surfaces. If machining a complex bottom surface is needed, a lens-shape end mill offers a good solution. This tool features barrel cutting edges on its end surface to ensure milling with a large stepover.

The barrel end mills – classic barrel-, oval- and lens-shaped cutters – provide efficient tools for machining 3D surfaces. Nevertheless, for a long time the complexity of CNC programming for applying barrel end mills was a constraining factor in actively integrating these promising tools into the appropriate branches of the metalworking industry. The growing use of 5-axis machine tools and the latest progress in CAM software has changed the situation dramatically, and today we see intensive utilization of barrel end mills in manufacturing various parts with geometrically complex surfaces. The main consumers of these "cutting barrels" are producers of aerospace, die and mold, medicine, turbine and compressor components.

Cutting tool companies in turn have strengthened their efforts to develop and manufacture more advanced barrel end mill designs to meet increased customer demands. Some of ISCAR's latest products, barrel end mills in the SOLIDMILL and MULTI-MASTER families, offer good examples of this

trend.

The MULTI-MASTER Advantage

ISCAR offers oval- and lens-shape end mills in diameter ranges of 8-16 mm and .312-.500" (Fig. 2). In addition to their availability in sold carbide design configurations, the new barrel end mills have been manufactured as exchangeable carbide heads with MULTI-MASTER threaded adaptation. MULTI-MASTER's distinctive "no setup time" feature, which enables the replacement of a worn head without withdrawing a tool from the machine spindle, can be particularly effective in the case of barrel tool applications in semi-finish and finish milling operations.

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Additional factors in favor of applying the MULTI-MASTER concept to barrel end mills are economic feasibility and sustainability. Due to the complicated shape of its cutting edges, a barrel end mill is designed as a throwaway tool – when the wear limit is reached, the entire carbide end mill simply becomes waste. In contrast to solid tools, the MULTI-MASTER design provides a valuable option for careful and cost-effective use of cemented carbide materials. And, of course, a rich variety of available MULTI-MASTER shanks, reducers and extensions enables optimal assembly of a required tool from these elements.

At present, barrel milling cutters are not in incredibly high demand by the metalworking industry; they are intended for very specific parts and effective application of such cutters requires highly engineered multi-axis machines and, especially important, leading-edge CAM systems. However, advanced workpiece manufacturing technologies (such as metal injection molding, 3D printing, investment

casting and close-tolerance forging), innovative machine tools, and a quantum leap in digitizing of manufacturing will increase the needs for finishing complex surfaces with minimum machining stock. In this light, ISCAR's specialists estimate that barrel end mill consumption in the metalworking industry will increase exponentially, and cutting tool manufacturers should be shaping up to what is evidently a promising new industrial trend.

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