Milling

A Welcome Power Cut

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The quest for reducing levels of power consumption in the global metal cutting sector is not a new trend; today it has become an essential technical requirement. Industry's greater understanding of its environmental protection and sustainability responsibilities has ensured the development of processes, materials and machines that significantly reduce power consumption during machining operations.

In addition to ensuring more efficient machining strategies, when compared to their heavy-duty predecessors, modern machining centers require less power whilst delivering improved performance capabilities. Previously, a typical production process was divided into primary and final cutting tasks that were performed on two machines. The first powerful machine removed most of the stock, and a more precise procedure was then used to achieve the final required shape and to create the necessary surface finish. Today, a single process often achieves these results in half the time. Fast and less load machining results in increased productivity and consumes less cutting power. In addition, the reduction of power means that the forces acting on the machine's main units (spindle, guidelines, etc.) are cut, which improves tool life and makes machining much more accurate and predictable.

Cutting tools have a major role to play in this area. Total power requirements can be moderated by the use of advanced new tools. In particular, innovative milling tools offer promising opportunities.

Leading-Edge Cutting Geometry
When milling, power consumption depends on several parameters, including workpiece material, depth and width of cut, cutting speeds and feeds. A combination of these influences defines the material's resistance to machining, and therefore the total cutting force generated during the process. There is one more important factor closely connected with these forces – the geometry of the tool being used; more specifically, the tool rake angles in both normal and axial directions.

The standard rake significantly affects the tangential cutting force and is the main determinant of the cutting power required if all other parameters are equal. The axial rake has an effect on resolving the total cutting forces into components and, therefore, acts on the tangential cutting force as well. With respect to milling cutters carrying indexable inserts, the rake angles are defined by the topology of the insert rake face and the insert positioning in the cutter. The topology is a key factor in varying rake angles.

In the early 1990s, ISCAR introduced the ***HELIMILL*** – a family of milling tools carrying indexable inserts with a helical cutting edge. The highly effective edge was generated by the intersection of the shaped insert top (rake) face and the helical insert side (relief) surface. The design of the HELIMILL tools formed a constant positive normal rake and a positive axial rake along all cutting lengths. This feature immediately caused a significant reduction in power consumption and ensured a smooth cut. Thus, the HELIMILL heralded a new design approach that is considered today as the acknowledged format in indexable milling, and put the shaped rake face of an insert into the forefront.

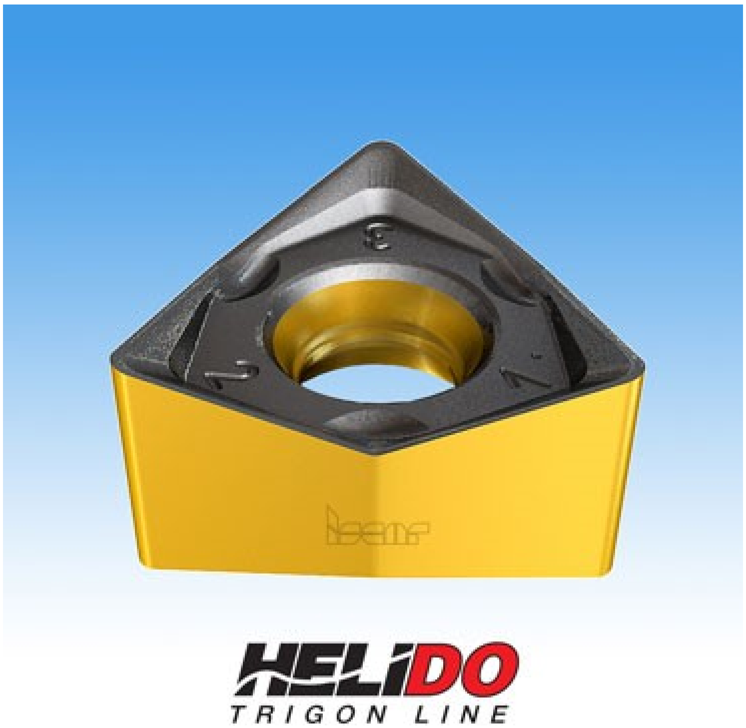

Fig. 1

When attempting to increase the rake, a tool designer seeks to incline the rake face of an insert more aggressively with respect to its cutting edge. However, in this area there is a serious limitation in that this incline weakens the insert's cutting edge and therefore has a negative impact on strength. The helically formed edge causes a difference between the heights, which are measured in adjacent corners of the insert. Producing such uneven sintered products is not a simple task and its creation requires serious technological efforts. Today, advances in powder metallurgy provide many more opportunities for increasing both the inclination of the rake face and the helix angle of the cutting edge, all without loss of strength. ISCAR's insert ***H690 WNMU 0705*** (Fig. 1) is a good example of the steeply inclined different-in-heights rake face of an insert that enables lower power consumption. The increasing use of the term "high positive" when describing modern milling inserts emphasizes the dynamic changes in indexable topology. Such a definition reflects the current state of the art. As the production of tools with cemented carbide inserts does not deplete topology resources, we may assume that the "high positive" of today will be considered as "normal" tomorrow. Increased optimization of the topology will lead to an additional reduction in cutting power.

Run Faster With Less Power Demand

It is commonly believed that machining at full capacity is an effective means for improving productivity. Rough milling deep cavities with the use of extended flute cutters or face milling by large-sized shell mills at a large axial depth of cut, when stock per pass is considerable, are typical examples of such an approach. These operations provide a high metal removal rate (MRR) but are evidently power-intensive, as milling under such conditions requires a significant cutting force and necessitates the utilization of machine tools with heavy-duty main and low feed drives. In this case, high efficiency is ensured by removing material of maximum possible cross-section at low to medium feeds.

Fig. 2

At the same time, another rough milling technique proposes a diametrically opposite principle: the combination of a rapidly running tool with a shallow depth of cut. In this case, power consumption drops dramatically with no loss in productivity – the tool works at extremely high feeds, guaranteeing efficient metal removal. This energy-saving shallow-cut "fast" technology provides a good alternative to power-consuming, deep-cut "slow" technology. High feed milling (HFM), which can be successfully realized on modern, light-duty fast moving machines, has delivered a serious and sustainable alternative to the traditional yet power-consuming approach.

HFM ("fast feed") tools feature specific geometry (Fig. 2). ISCAR offers them in all the company's milling lines: indexable, solid carbide and Multi-Master (a family of assembled tools with replaceable cutting heads produced from cemented carbides). In addition, ISCAR has introduced inserts that, when mounted on general-use indexable end mills or face mills, turn into HFM tools. Such a transformation is a way to simply adjust various cutters from ISCAR's standard line for fast feed milling.

Alternative Machining Strategies Challenge Deep-Rooted Techniques
Substantially expanded opportunities for modern machining tools have led to new milling strategies that, amongst other advantages, reduce power consumption.

An example is turning heavyweight parts. When turning, cutting speeds are traditionally ensured by rotating a part. If the main drive of a machine tool is unable to rotate a part of large mass with the required velocity, the achieved cutting speed will fall short of the necessary range. Such a limitation causes a loss in performance in turning operations. Today, advanced multifunctional machining tools offer an effective solution: turn-milling, a method combining milling and turning, where a milling tool cuts a rotating workpiece. The majority of ISCAR indexable face mills and end mills can be applied to turn-milling; however, correct tool positioning and the calculation of cutting data require a more profound understanding of the specific features of this process.

Fig. 3

The conventional milling of slots or grooves starts from the machining of solid material directly at full tool engagement. Milling with full tool engagement requires increased cutting forces and, consequently, consumes more power. A high speed trochoidal milling technique can be a worthy alternative to the common slot milling strategy. In trochoidal milling, a rapidly rotated tool machines the slot by arc motion at a significant depth of cut and very small width of cut. The tool slices thin layers of material with both high speed and high feed rates. This productive method features a noticeable reduction in power consumption. It is no wonder that trochoidal milling has been utilized successfully in manufacturing parts with complicated slots and grooves, such as blisks (bladed disks), blings (bladed rings), impellers, etc., especially those with relatively thin walls. ISCAR has recently introduced Ti-TURBO – a family of solid carbide end mills ECK H7/9-CFR that have a unique cutting geometry with 7 or 9 flutes, different helixes and a variable angular pitch (Fig. 3). The main application of the new family is trochoidal milling workpieces, which are made from difficult-to-cut titanium grades.

Applying new machining strategies with correctly chosen milling tools creates new opportunities for power saving. Reducing machining power is one of the necessary conditions of modern manufacturing. The latest machine tools provide the metalworking industry with the means suitable for high performance and energy-efficient technology. The sustainable cutting tool not only cuts metal productively but also cuts power consumption – a major factor in ISCAR's success.

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