Milling

Milling Aluminum Intelligently

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Milling aluminum appears to be a remarkably easy process. Often, people who are not directly involved in machining aluminum hold misguided views. They believe that it's enough to take a balanced, sharp, polished tool and rotate it at a maximal speed, set at medium feed and the material will cut like butter.

In comparison with machining steel, aluminum and its alloys require much less cutting force, and therefore the cutting edge of a milling tool experiences relatively low mechanical loading. For the purpose of this article, Iscar refers to aluminum and its alloys as aluminum. Aluminum exhibits high thermal conductivity and therefore the chips produced when machining aluminum transfer high levels of generated heat, resulting in significantly reduced thermal loading of the cutting edge. Due to these properties, milling aluminum is characterized by extremely high cutting speeds and feeds. Nonetheless, this does not guarantee that milling aluminum is quite so simple.

The material characteristics of aluminum result in the formation of built-up edge (BUE) when machined. This unwelcome phenomenon increases the mechanical load on the cutting edge making efficient chip flow more difficult to achieve, affecting the balance of rotating tools and causing the entire machining process to be less efficient.

The evacuation of aluminum chips may also be affected by using the wrong kind of cutting tool. If the volume of a tool's chip gullet (flute) is not sufficient, the long chips during aluminum milling will clog the tool. Overcoming this obstacle demands the use of a tool with less teeth or reducing the applied cutting data, actions that negatively impact productivity.

From a machinability point of view, aluminum is not a material that is uniform. Alloying elements (in particular, silicon), material type (wrought, cast) and treatment methods all affect cutting properties. Multiple other factors such as the shape of a machine part, workholding conditions and operational requirements (accuracy, roughness, etc.) add their own limitations and must be considered when choosing machining strategies and selecting a tool. Hence, in many cases, machining aluminum in general and milling aluminum, in particular, are often not the simple tasks they appear to be.

Tool manufacturers take the specific features of milling aluminum into consideration when developing cutters. A key to success is the correct combination of cutting geometry, tool material and tool treatment, in addition to the options for delivery of optimum coolant supply.

When considering applications for milling aluminum, large aircraft components, such as wing elements, door or window frames, etc. come to mind. Generally, these parts are produced from whole blocks, often weighing several tons, and it is often necessary to remove up to 80-85% of the block weight to produce the final required shape of a component. In contrast, the global automotive industry, which is also a massive consumer of aluminum, has introduced various hard-cast aluminum grades to their components. The increased abrasiveness of these parts negatively affects tool wear.

ISCAR, a full-line supplier of cutting tools, has developed an entire comprehensive range of indexable milling cutters, designed specifically for the efficient machining of aluminum. Each family of these high-quality cutters features integral or lightweight body designs, unique principles of carbide insert clamping, structures with adjustable cartridges, various ground and polished inserts with different corner radii and, most popular in aluminum machining, inserts with polycrystalline diamond (PCD)

tips. The vast majority of the cutters have inner channels for coolant supply through the body. The ISCAR HELIALU line of indexable milling tools enables efficient high speed machining (HSM) of aluminum, ensuring powerful metal removal rates (MRR), high accuracy and excellent surface finish characteristics, all of the qualities demanded by the world's producers of aluminum components.

Metalworking industries produce large and small aluminum parts, and in many cases require milling cutters with more modest dimensions. The size of these tools is not suitable for indexable inserts and solid carbide tools have distinct advantages. Moreover, the high accuracy of solid carbide end mills renders them beyond comparison when used in precision finishing of larger components. Therefore, ISCAR remains heavily involved in the design and development of advanced solid carbide tools for the milling of aluminum. Recent progressive additions to this all-embracing range have further increased their value to users throughout the industrial world.

ISCAR's ECR-B3-R-C family of 3 flute, solid carbide end mills are designed for rough machining at high MRR. The innovative end mills have serrated cutting edges that divide wide chips into narrow chips that are easily evacuated. Inner coolant channels directed to each cutting edge enable the delivery of uninterrupted coolant flow to the cutting zone. These two design features, in combination with polished flutes, significantly improve chip evacuation abilities, allowing considerably increased productivity. The serrated edge that chops the chips also enhances vibration resistance, and together with the relieved neck of the end mill contributes to stable cutting under high tool overhang conditions.

Why does the ECR-B3-R-C family have 3 flutes and no more? In milling aluminum, chatter and unwelcome vibrations that are generated during the cutting process are a factor of primary importance. Various researches and metalworking practice show that a 3 flute configuration is the optimal design for 90° solid carbide end mills for machining aluminum. In high-efficiency milling, this arrangement ensures a flute volume that is necessary for chip flow, whilst it does not increase chatter. The majority of the end mills for use on aluminum are based on this approach and ISCAR's ECR-B3-R-C is no exception.

At the same time, the desire to increase the productivity of end mills led to the launch of an innovative 4 flute ISCAR design. CHATTERFREE ECA-H4…CF is a family of end mills that provides an extra flute to help increase MRR for both roughing and finishing operations. Although a 4 flute structure, these end mills have impressive vibration dampening abilities due to the inclusion of a non-equal flute helix and the variable angular pitch of its teeth. Also, ISCAR's tool designers succeeded in creating a core diameter and the cross-section area of a flute, similar to the already existing 3 flute end mills of the same diameter from the ECA-H3 family.

The die and mold and aerospace industrial sectors need small-size milling tools for the precise machining of 3-D surfaces. A newly introduced family of solid carbide ball nose end mills—EBA-B2—with polished flutes and a diameter range of 1-6 mm, is intended precisely for these kinds of demanding applications. The new family extends the lower range of the 8 to 25 mm diameter MULTI-MASTER MM EBA replaceable ball nose heads.

The MULTI-MASTER family of assembled tools, comprising shanks of different configurations and a great variety of replaceable cutting heads, is ideal for milling aluminum, especially in applications requiring the high overhang of a tool. Long-reach solid carbide end mills are produced from expensive carbide rods of considerable overall length. Despite the small fluted part of an end mill being directly involved in cutting, after tool wear or a sudden breakage, the whole expensive rod needs to be thrown away. This is a serious economic disadvantage. In contrast, in such cases,
MULTI-MASTER users only need to replace the cutting head.

To conclude, it is fair to say that milling aluminum is easy, if performed intelligently! Apply an efficient cutting strategy and use ISCAR's correctly chosen milling tools for successful results.

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