by: James Kim
Wire Applications Engineer
GF AgieCharmilles

Applying 5-Axis MACHINING to HSM&EDM

Illustration #1
This demo part was machined on a Mikron HSM 400U to demonstrate the true ability of 5-axis machining.

For American manufacturers, the current state of affairs provides an excellent time to invest in new technology. High oil prices have raised the cost of transportation, making domestic manufacturing more appealing for goods sold in the US. At the moment, the low value of the dollar has provided an advantage to producing goods within our borders. Eventually, our currency will rebound and this particular competitive edge will disappear, but for now, it offers a significant opportunity.

In addition to less direct factors, the government is now offering a stimulus package of tax incentives to promote capital investment. Now is the time to adopt new technologies and establish long-term competitive advantages, but which investments will provide the largest benefits?

Over the past several years, the maturation of 5-axis machining has allowed it to create substantial opportunities for manufacturers pursuing the cutting edge of technology. While talk of 5-axis has become somewhat common in regards to high speed milling, less is reported on the strides made in 5-axis EDM. When evaluating expected return-on-investment, it is important to understand the benefits that each of these innovations offer.

5-Axis High Speed Milling

Traditionally, high speed machining was limited to 3-axis machining in the X, Y and Z axes. An endmill would be placed in the upper head spindle, which in turn would rotate to a maximum rate of up to 42,000 RPM. Cutting would take place by moving the cutter in the X, Y, and Z axes around a part clamped to the stationary work table. The advantages of using a high speed spindle were clear in hard metal machining applications. Operators could achieve faster machining speeds, superior levels of accuracy and high quality surface finishes.

Breakthroughs in the design of high speed machining processes led to the implementation of simultaneously milling with two extra axes. In addition to the X, Y and Z axes, B and C axes could be utilized. While the concept can initially prove complex to envision, it is made easier to understand by separating the process into two portions, one containing the traditional axes and one containing the new axes, or 3 axes + 2 axes.

The new B and C axes control rotation and tilt orientation of the table where the workpiece is mounted. This is in contrast to the traditional, stationary table. The B-axis controls rotation of the table with the center of the table's rotational axis parallel to the Y-axis of upper head movement. Likewise, the C-axis controls rotation of the table with the center of rotation parallel to the Z-axis. The easiest way to remember the orientation of the new axes view the A, B and C axes as respectively and alphabetically corresponding to the X, Y and Z axes. Thus, it makes sense that the B-axis rotates around the Y-axis and the C-axis rotates around the Z-axis.

Overall, in 5-axis machining, the endmill in the upper head travels in the X, Y and Z axes, while the part can simultaneously be rotated in the B and C axes via synchronized rotary motion or at an indexed and tilted orientation. This provides two additional dimensions to existing 3-axis milling. While programming a part for simultaneous 5-axis machining can seem a daunting task, it can be achieved via a number of user-friendly milling CAD/CAM software packages that have become available.

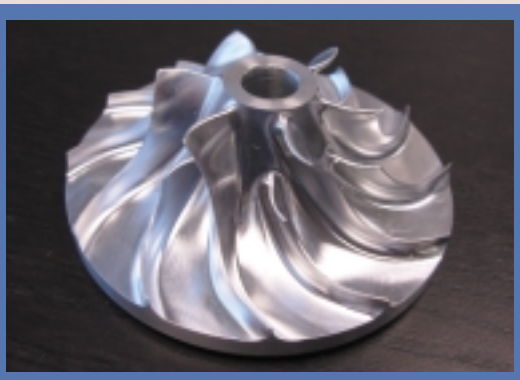

Illustration #2
The combination of high speed machining and 5-axis technology offers considerable value when producing 5-axis Impellers.

To view examples of the end product of 5-axis milling, refer to ***illustration #1*** and ***illustration #2***. A statue and 5-axis Impeller, respectively, these parts were made on a high speed milling machine equipped with 5-axis capabilities. The statue is a demo part, machined in aluminum. It demonstrates the capabilities of true simultaneous 5-axis machining, achieving a high surface finish on a complex 3D part with multiple curvatures, all in a single setup.

5-Axis EDM

As technology has progressed to a new level, wire EDM has also moved away from traditional machining processes. This innovation has come through the integration of a B-axis control that is similar in many respects to 5-axis milling.

When implementing new B-axis technologies with wire EDM, an operator can use indexed or Turn while Burn rotary processes. Both of these involve rotating the part around its center to achieve geometries that were previously impossible to attain with wire EDM.

Similar to 5-axis milling, a wire EDM with a B-axis can be utilized in two distinct ways. With an indexed B-axis, the part is rotated between cuts. With Turn while Burn, rotation can take place simultaneously with movement along the X, Y, U and V axes. Because the rotary B-axis is controlled and synchronized during the wire EDM erosion process, extremely complicated part geometries can be machined.

Illustration #3
Turn while Burn technology makes it possible to machine this helix screw on a wire EDM.

Illustration #4
This complex demo part illustrates the complicated geometries that can be achieved through 5-axis EDM.

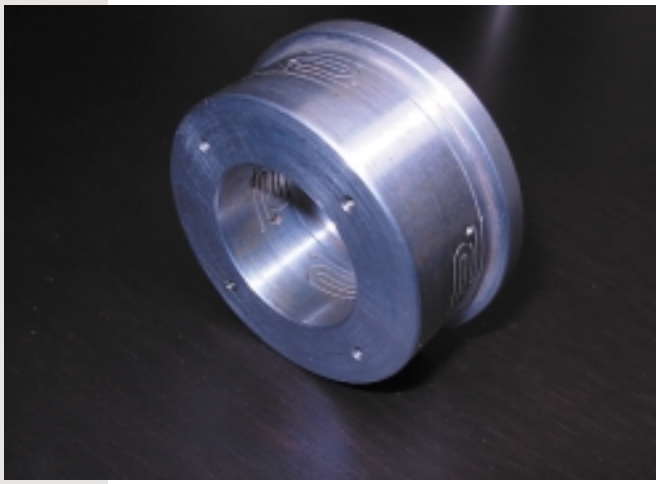

Illustration #5
The small, complicated slots in this squeeze film damper were produced almost exclusively through B-axis movement on a wire EDM.

Illustration #3 demonstrates a helix screw that can be machined using wire EDM with Turn while Burn functionality. The part was produced on a wire EDM programmed for eight continuous revolutions or 2,880-degree rotation. The Turn while Burn ability proved extremely beneficial in the production of the helix screw. ***Illustration #4*** shows a more elaborate example, where the rotary B-axis servo was synchronized with the X, Y, U and V axis servos. This demo part was machined using both B-axis indexing, along with the Turn while Burn capability.

In ***Illustration #5***, a patented Squeeze Film Damper is displayed. This part was machined with wire EDM and required both types of B-axis movement. The part was indexed for multiple cutting operations and then rotated while the X and Y axes maintained a virtual standstill. The latter of these processes created the complicated slots between the X and Y profiles. The part required a total of 4 predrilled start holes with 2 sets of holes positioned 90-degrees to each other on the side wall of the component. The rotary B-axis allows for unattended automation in the manufacture of the part.

Selecting the Right Technology

The time is perfect for investing in new equipment and the only real question is which technologies will provide the greatest benefit. For most manufacturers, there is great potential in 5-axis technology, for both milling and EDM. By carefully evaluating the advantages of both and analyzing how they would complement current capabilities, American manufacturers can turn the current situation into a long-term competitive edge.