EDM STRATEGIES FOR ODD POCKETS

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The wire EDM market thrives on complex shapes that are difficult, if not impossible, to cut by any other means. However, that challenge can become a real chore when geometry is too complex to remove easily in one piece.

One option is to remove sections of material bit by bit with cumbersome geometric manipulations and multiple machining operations. A better choice is to let a computer-aided manufacturing (CAM) system perform an intelligent calculation of the geometry and then generate the simplest, most intuitive wire path possible to effortlessly remove a complex shape.

**Divide and Conquer**

A classical approach to problems of great complexity is to “divide and conquer”. This technique proves itself time and time again because, quite simply, it works.

To know how to divide and conquer requires a skillset that involves in-depth knowledge of the capabilities of wire EDM, knowledge of the different cutting processes that can be applied, and the experience to know which cutting processes will work best based on the geometry of the given workpiece.

For a skilled programmer working without assistance from an advanced CAM system, it could take several hours to produce the correct geometry and generate the wire path for an odd shape with complex tapers.

Working with the assistance of a CAM system that uses advanced algorithms to analyze all the shapes involved and then use that analysis to calculate the most efficient wire path can reduce that time to minutes. That’s time that can be spent burning metal instead of burning brain cells.

ESPRIT uses the logic of “divide and conquer” to analyze and split complex pockets into smaller, separately defined zones that can be easily cut with adaptive 4-axis EDM strategies.

**Cutting to the Core**

The first step in the analysis of a complex profile is to identify the two basic areas that need to be cut:

- The core
- The shell

The core represents the largest area that can be removed with simple 2-axis wire path.

The shell is the remaining area between the core and the desired outer profile.

Two areas on the model are initially identified: the core and the shell. The core represents the largest area that can be easily removed with vertical wire path. The remaining shell area can then be removed with 4-axis no-core pocketing wire path.
Core or No Core?

A “Core” strategy is ideal when the shapes of the UV and XY profiles are different. It is even better when the core can be removed as a single slug drop.

The largest area that is common to both profiles is calculated and then the user can choose whether the core is burned as if it was a vertical 2-axis no-core pocketing cycle or the slug is cut and dropped as if it was a vertical 2-axis contouring cycle. When the slug is dropped, the user can specify a cut-off distance and the type of stop to output in the NC code.

After the core has been removed, the shell areas still need to be cut. An advanced morphing technique gradually adjusts the shape of the wire path from the core profile to the shape of the outer profile.

As with the core, the user can choose how the shell area is removed. This choice will mostly depend on the shape of the cavity.

When the thickness between the core and the outer profile is relatively uniform, the entire shell is burned with an advanced morphing technique that gradually adapts the shape of the wire path from the inner core to the shape of the outer profile.

When the thickness between the core and the shell area is uneven, there is a risk of over-burning in the thinnest areas.

In such cases, the user can choose a “non-uniform” strategy that will split the shell into smaller, more uniform pieces. The system uses the synchronization match lines on the outer profile to determine where to split the shell. Each shell piece is then burned separately using the same morphing technique.

It should be noted that not all 4-axis shapes can be cut effectively with a 4-axis pocketing cycle. The programmer must examine the EDM4 shape from the top view. If any of the synchronization match lines intersects either the XY or UV profiles (excluding the connection points) then you may have an undesirable “heavy twist” situation.

Parts with heavy twist may drop a small core of material which is due to self-intersection of the surface generated by the wire as it moves along its path.
A "No Core" strategy works best when the UV and XY profiles are similar. In this case, a "core" is not required. Instead, this strategy uses the shape of the XY and UV profiles to calculate each inner core profile. The idea of the "No Core" strategy is to match each synchronization point from the outside shell to an equivalent inner core point.

The number and locations of the synchronization lines on the outer profile are critical to the calculation of the inner core profile. Enough synchronization lines must exist between the UV and XY profiles to allow the CAM system to calculate an appropriate inner core profile. The integrity of the part surface could be impaired when an insufficient number of match lines are programmed.

The entire shape is then burned with a no-core pocketing wire path. Instead of using a standard offset tool path that could potentially cause problems with self-intersecting tool path, the tool path is generated by morphing the shape of the inner core profile and the shape of the outside shell.

Getting there from here

A common issue with complex pockets is that the geometry simply does not allow the wire to be threaded in a standard vertical orientation. In that case, the wire must pass through a tilted thread hole at the start of the operation.

In ESPRIT, the features for 4-axis EDM can be modified to tilt the thread angle. The user can add a new thread line to the feature by selecting an upper thread point and lower thread point to define virtually any angle.

At the beginning of a 4-axis operation with a tilted thread:

1. The unthreaded nozzles move to a vertical position at the lead-in point of the feature.
2. Then, each nozzle moves to the appropriate position at the upper and lower thread points of the tilted thread line.
3. The nozzles stop in preparation for threading.
4. The wire is threaded. For the majority of machines, the wire must be threaded manually.
5. The selected entry move is then performed.

For a cutoff move, the wire will not go back to a vertical position but will keep the same tilt as the last position on the profile.

At the end of the operation:

1. The wire returns to the tilted thread line.
2. The wire is cut.
3. The nozzles move to vertical at the lead-out point of the feature.
Skeletons are not scary

It should never be assumed that all part profiles will have ideal shapes that lend themselves to an easy calculation of an inner core profile. Sometimes it is not possible to reach all areas of the outer profile from a single inner profile or thread hole. Trying to synchronize the outer profile, where all synchronization match lines are defined, to an inner circle will yield unacceptable looping passes. In that case, a part violation is inevitable and a different method needs to be used to calculate the inner core profile.

To accomplish no-core pocketing, the outer profile must be synchronized against some kind of internal core profile. To that end, any zone within a pocket can be connected to a calculated inner profile in a straight line without intersecting the XY or UV profile.

When ESPRIT detects areas along the outer profile that cannot be synchronized with the core, the system calculates what is called a “skeleton” profile.

The concept of the skeleton profile is that any pocket profile can be broken into smaller articulated units (or sub-systems). Each sub-system then has its own spine profile. Where two or more sub-systems overlap they are connected by a shared node.

A “skeleton” profile breaks down each zone of the pocket into a sub-system and calculates a separate inner profile for each zone using the synchronization points on the outer profile. Where two or more sub-systems overlap they are connected by a shared node.

When all local inner profiles are connected together, they form a single “spine” profile. This spine profile is then used to synchronize the toolpath with the outer profile.

In a single CAM function, wire EDM programmers can have the options they need to machine virtually any complex shape in an intuitive and effortless way.

This can only be accomplished when the software developer does an in-depth analysis of each step in the process programmers use to generate wire path. It also requires real-world experience working with the EDMs that are used today on the shop floor and by partnering with machine tool builders to get a firsthand look at the machines being developed for tomorrow. This analysis effort lends itself to a high rate of reliability in the resulting software, which ultimately benefits the user.