***TechTips** is a collection of useful ideas, techniques, and procedures designed to further EDM knowledge.*

TechTips

by Roger Kern

FLUSHING Fundamentals

The old adage about "The three most important things in EDM are Flushing, Flushing, and Flushing" still rings true, because if we don't remove the eroded material and electrode debris from the gap, the process will grind to a halt. EDM is similar to other forms of machining, in that it removes material but does not obliterate material. Therefore, EDM debris must be transported away from the cutting area just as chips must be removed from the milling area. Otherwise, the EDM debris or chips will be re-machined again and again, preventing the machining process from proceeding. In this issue, we will examine the more common flushing techniques employed in Sinker EDM applications.

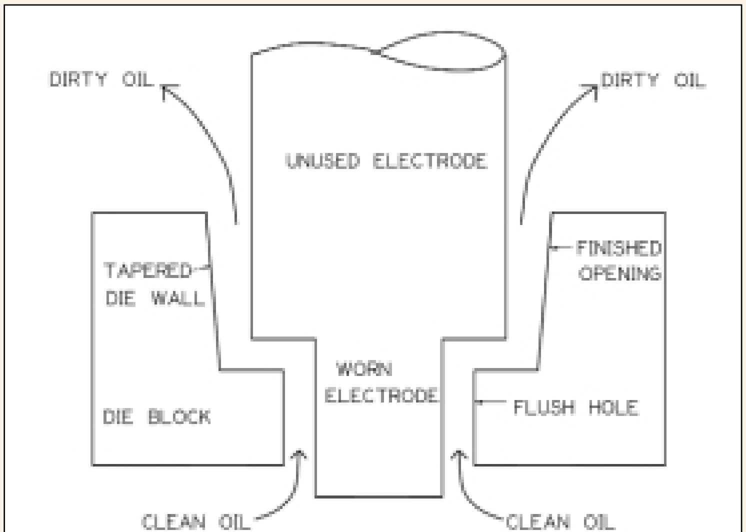

Figure #1

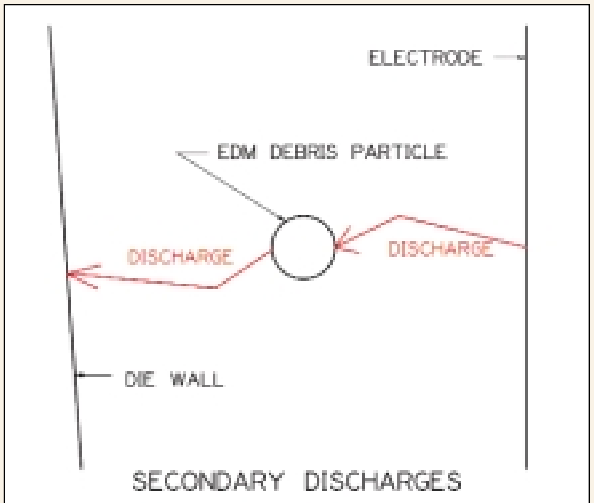

Figure #2

Positive Flushing

The best method of flushing a Sinker burn is to force a continuous flow of oil across the cutting gap, which is called Positive Flushing. By employing Positive Flushing, the EDM process is allowed to proceed as a continuous series of discharges at maximum efficiency, since the debris is continually removed from the gap. This allows the discharges to be evenly distributed across the entire surface of the electrode without interrupting the process for Ram pulsation, or causing the power supply to make speed reducing waveform adjustments to compensate for poor flushing conditions.

Let's examine the different possibilities for Positive Flushing:

❑ **Cavity burn with pressure flush from the bottom *(See Fig #1)***

This is the most commonly used Sinker EDM flushing condition. However, it is not the best one, since it results in tapered cavity side walls, extra electrode wear, unpredictable overcut, and degraded cavity finish, due to the results of secondary discharges. ***(See Fig #2)*** These secondary discharges are the result of dirty oil flowing between the unworn electrode and the finished cavity walls.

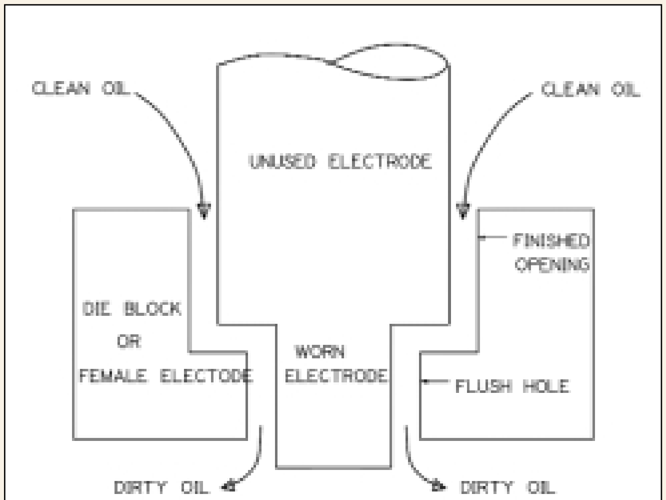

Figure #3

Please note the following rule for Positive Flushing:

Design the flushing setup so that there is always clean oil between the unworn electrode surface and the finished cavity surface.

❑ **Cavity burn with vacuum flush from the bottom *(See Fig #3)***

Note that by reversing the flow of flush, we now have clean oil between the unworn electrode and cavity surfaces, eliminating the possibility of secondary discharges. The only disadvantage of vacuum flushing is that the flushing pressure is limited to atmospheric pressure, or 14.7 psi. For most applications, this should not be an issue.

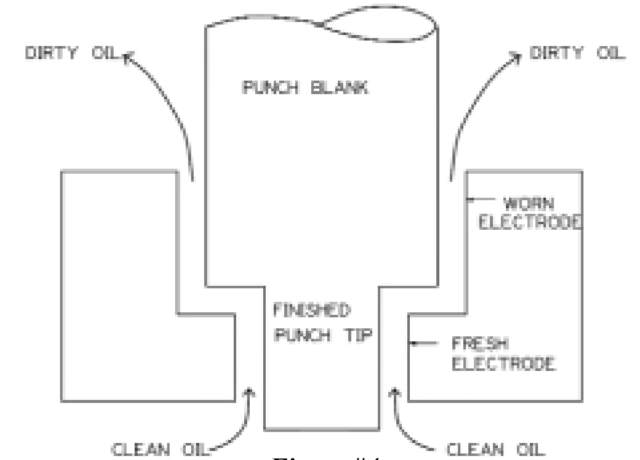

Figure #4

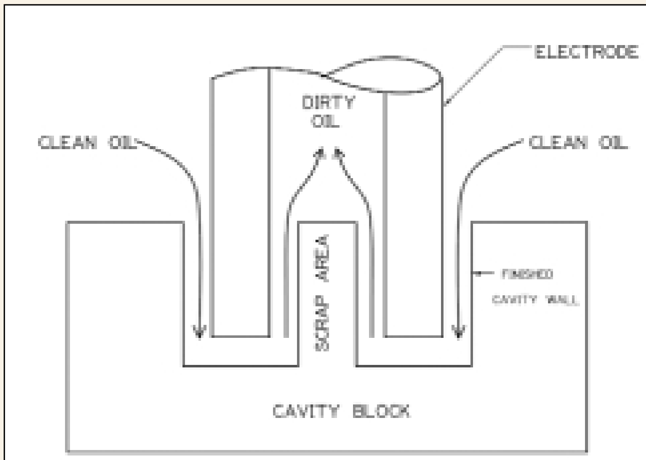

Figure #5

❑ Punch Reverse Burn with pressure flush from the bottom *(See Fig #4)*

Using pressure to burn a punch appears counter-intuitive until one realizes that the whole process has been turned upside down. That is, the work-piece (the punch) is now mounted on the Ram, and the electrode is mounted in the tank. Thus, using pressure from the bottom satisfies the Positive Flushing rule.

❑ Cavity burn with flush hole in the electrode and vacuum from the Ram
(See Fig #5)

While this is an unusual application of Positive Flushing, the flushing rule is still satisfied.

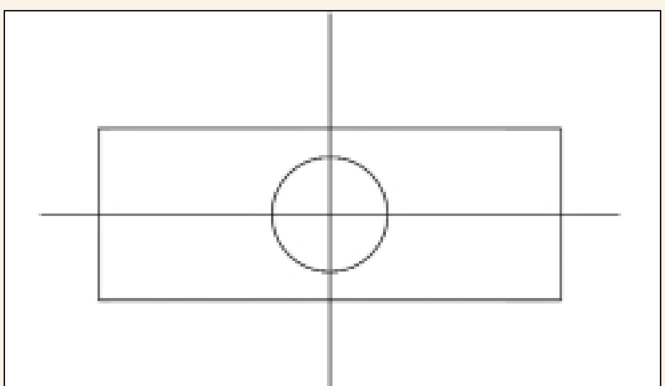

Figure #6

✓ Flushing Hole Location

Please note the following rule for flushing hole location:

Efficiency and accuracy of burns will be maximized when the distance from the flushing hole(s) to the point of EDM is equidistant.

Fig #6 represents the most common example of a flushing hole for a cavity burn. The hole is located in the center of the cavity and made as large as possible. This is readily accomplished with no additional calculations, as the centerline of the cavity is already specified. However, please note the disparity in the length of the flushing path in the X and Y directions. The left and right ends of the cavity will be "starved" for flushing.

The modification shown in ***Fig #7*** significantly improves the flushing situation with the addition of another flush hole, and the symmetrical layout of the holes about the cavity centerline. However, please note that the area in the center of the cavity is now starved for flushing.

Fig #8 reveals an optimized placement of the flushing holes for this situation. This methodology can be adapted for any number of holes in a row, or for rows and columns of holes.

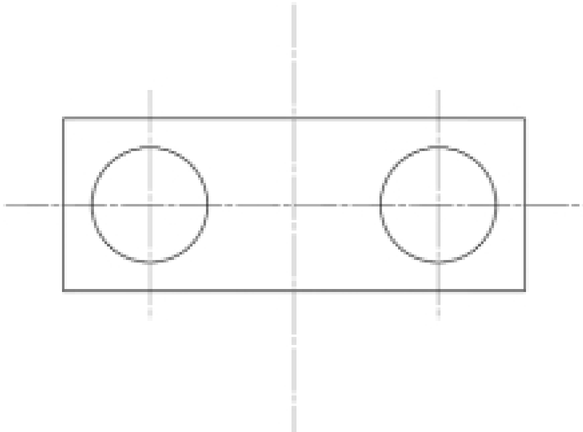
Figure #7

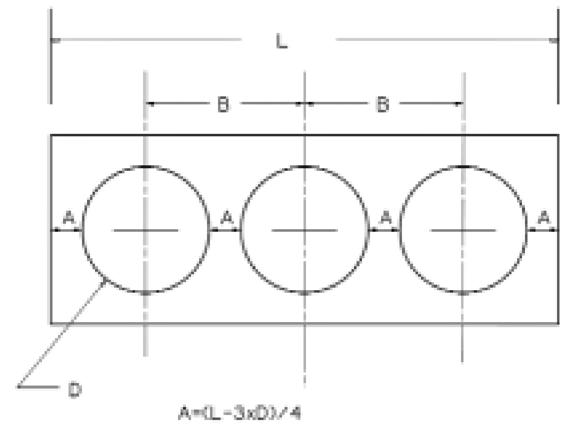

Figure #8

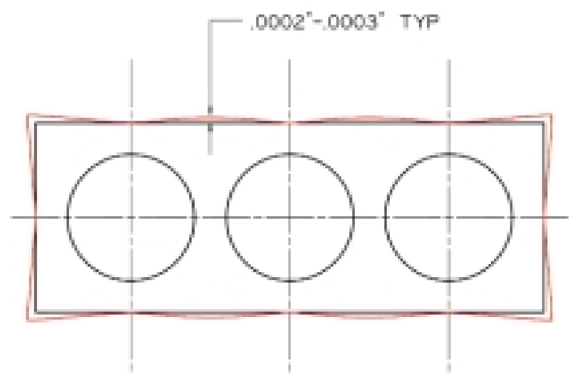

Figure #9

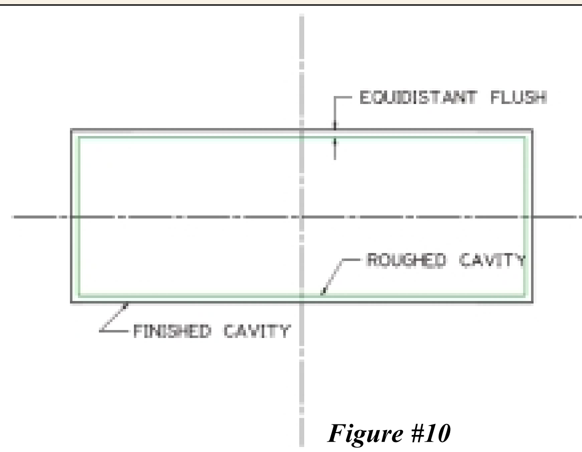

Figure #10

It is important to note that even this flushing layout does not completely satisfy the rule. As a result, if you were to accurately measure the cavity produced by the flushing setup in ***Fig #8***, you would find the errors depicted in ***Fig #9***. The overcut in the areas farthest from the flushing will be slightly greater than in the areas closest to the flushing. The difference is only a matter of a couple "tenths", but sometimes those tenths matter. The only way to completely satisfy the Positive Flushing rule would be to rough out the cavity uniformly undersized as shown in ***Fig #10***.

✓ The Flush Pot

A well designed and constructed Flush Pot is an essential Sinker EDM accessory when utilizing Positive Flushing. The Flush Pot serves three important functions:

- A mounting surface for the die block, cavity block, or female electrode. Beneath the mounting surface is a sealed cavity, which allows the electrode to pass through the workpiece (seldom needed since the advent of Wire EDM) or for the punch tip to pass through the female electrode.
- A source of pressurized fluid or vacuum. (Via the sealed cavity beneath the mounting surface)
- Connection points for the pressure, vacuum, and sensing.

The drawing in ***Fig #11*** illustrates all of these features. The top has a center cutout to allow for electrode and fluid passage. The inner tapped holes can be used for either flushing passage or mounting screws (unused holes are sealed with set screws). The outer tapped holes are for mounting

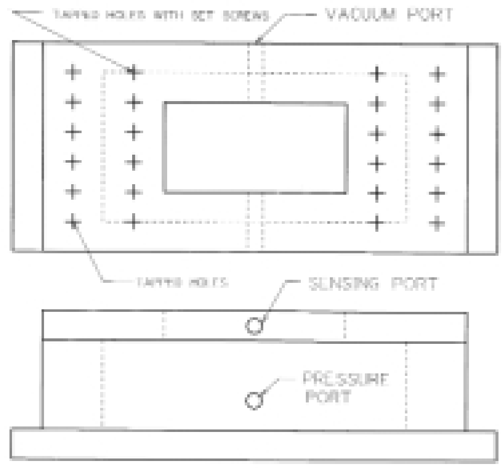

Figure #11

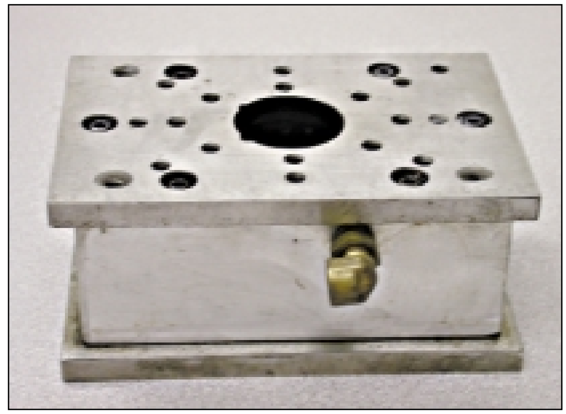

Figure #12

screws. The flanged base of the fixture allows for easy mounting to the machine table. The Flush Pot also has ports for pressure, vacuum, and sensing. Please note that the vacuum port is drilled into the mounting plate, directly opposite the sensing port. The vacuum port must always be located near the top of the flushing cavity to draw off the erosion gasses to minimize the potential for an explosion. The sensing port is also at the top of the mounting plate to assure that measurements are taken as close to the burning as possible. The pressure port location is not critical, but is usually located opposite and on a different plane from the vacuum port. Flush Pots have been made in welded, bolted, and cast configurations. Regardless of construction method, the top and bottom of the flush pot should be precision ground at assembly. Unfortunately, well made commercial versions are no longer available.

A small, well worn, "home made" Flush Pot is shown in ***Fig #12***. It features hardened and ground top & bottom plates, with an aluminum center section.

✓ Measuring and Regulating Positive Flushing

❑ Flushing Measurement

Flushing has been traditionally measured with pressure and vacuum gages. This technique is still commonly utilized today. In order to accurately monitor the flushing parameters, two rules must be followed:

- Take the measurement as close to the gap as possible.
- The measurement line should be independent of the supply line.

Usually, too much flushing causes as many problems as too little flushing. It is not uncommon to reverse burn punches at .5 psi to minimize electrode wear *(See Sept/Oct, 2008 Tech Tips)* or to burn narrow slots at 1-2" Hg of vacuum to avoid flushing induced electrode deflection or fluttering. To measure these small values, a high quality gage setup, designed specifically for EDM, is required such as that shown in ***Fig #13***.

Figure #13

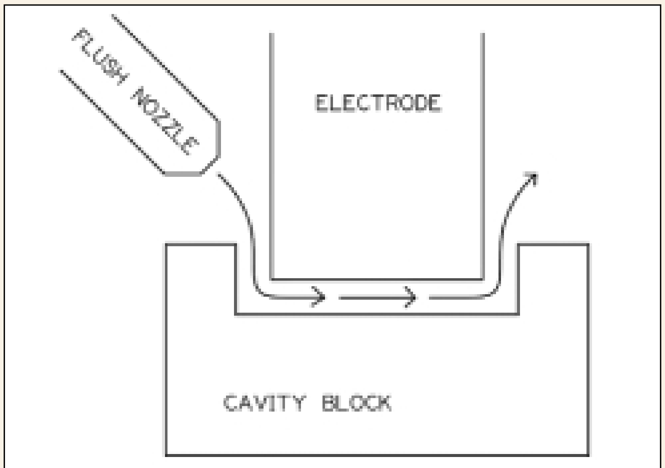

Figure #14

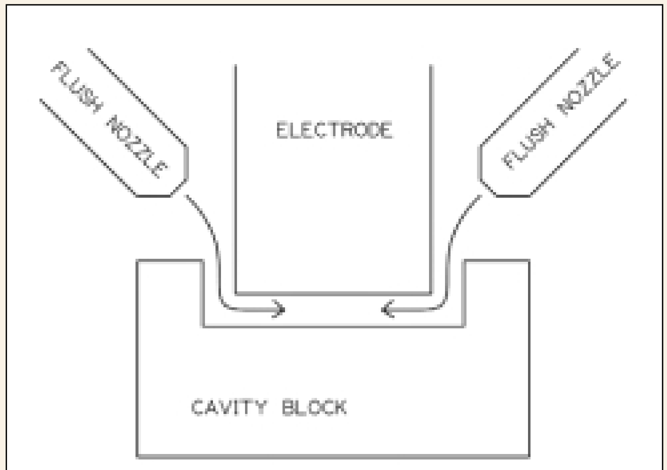

Figure #15

❑ **Flushing Regulation**

Maintaining constant pressure or vacuum is essential to successful Positive Flushing. Since a typical EDM gap is quite small, the actual volume rate of dielectric fluid passing through the gap is quite low. With a low flow of dielectric through the gap, it is usually necessary to keep the machine flushing valves set very low in order to maintain low pressure or vacuum levels. Unfortunately, a small change in the flushing gap (such as continually increasing depth of burn) can cause a significant change in observed pressure or vacuum.

A technique called Compound Flushing will overcome this problem. I learned this useful technique many years ago from our esteemed editor, Jack Sebzda Sr.

Compound Flushing is the simultaneous application of significant amounts of pressure and vacuum to the Flush Pot, whereby the resultant flow of dielectric fluid through the flushing gap is a small fraction of the total flow through the flushing valves. The desired net pressure or vacuum in the flushing gap is obtained by "over-riding" either the pressure with the vacuum, or the vacuum with the pressure, by adjusting the machine valves. Since most of the fluid flow is through the valves and not the gap, small changes in the gap will have little effect upon the observed pressure or vacuum. Compound flushing provides a simple, yet effective means of flushing regulation.

Indirect Flushing

In many cases, Positive Flushing is not possible when separate flush holes are not allowed, or cavity features such as ejector or core pin holes are not located in the area where the burn is required. We will now explore a number of alternative flushing techniques, which may be applied singly or in various combinations:

❑ **Splash Flushing**

Splash Flushing is the application of dielectric fluid by means of a nozzle (or nozzles) exterior to the burn. It is almost always used in combination with one of the other types of indirect flushing, which will be introduced later in this article.

The most common application of Splash Flushing is shown in ***Fig #14***. A dielectric nozzle is aimed at the intersection of the electrode and workpiece surfaces causing an induced flow through the machining gap.

Following the logic that "if one is good, two must be better", one might be tempted to apply a second nozzle to the other side of the electrode.

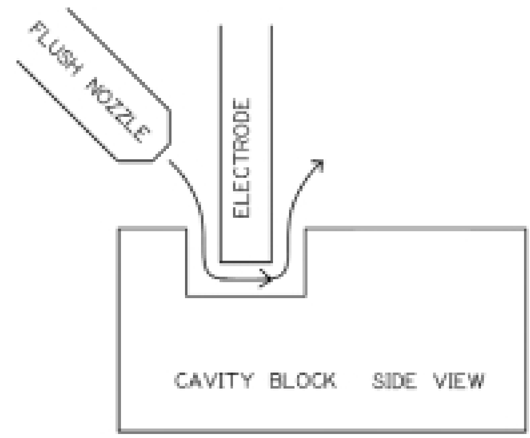

Figure #16

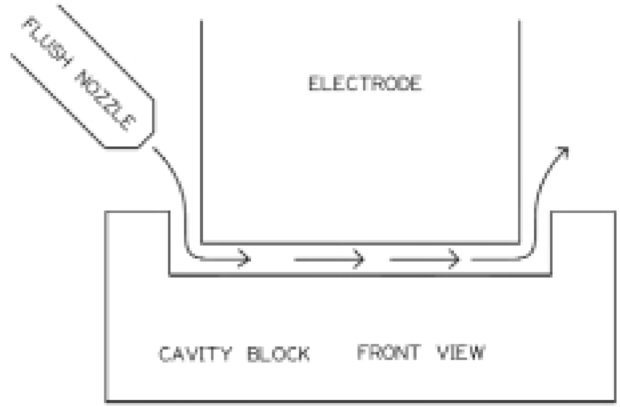

Figure #17

However, this may serve to trap the debris in the center of the cavity, impeding the burn rather than enhancing it, as shown in ***Fig #15***.

One should also consider the cavity geometry when applying Splash Flushing. For example, applying the flushing to flow across the narrow side view of the cavity block shown in ***Fig #16,*** as opposed to the longer front view of the cavity block shown in ***Fig #17,*** will provide a much shorter debris path to the dielectric bath and promote a much more efficient burn.

✓ Motion Induced Flushing

Relative motion between the electrode and the workpiece can create hydrodynamic forces that will induce dielectric flow, and thereby provide a means of flushing the gap.

❑ Pulsation

Pulsation retracts and advances the electrode along the direction of the burn. This is usually accomplished with the Z-axis motion of the ram, but is not limited to the Z-axis. (As we will see later, successful EDMing is not limited to the Z-axis). Pulsation is often combined with splash flushing for maximum effectiveness.

By retracting the electrode from the burn and advancing the electrode back into the burn, the "piston-like" motion generates dielectric flow, as well as getting the electrode out of the way so that the debris can escape from the cavity. This technique has been further developed on newer machines in the form of "high speed jump", in which the electrode is retracted and advanced at very high speeds, creating quite forceful dielectric flow.

Pulsation is often the most effective method of flushing when positive flushing is not possible. However, it is not a panacea, because of two significant considerations:

- While the electrode is retracting and advancing, cutting is interrupted. The inactive time can be as much as 50% of the total time, lengthening the burn time substantially, when compared to Positive Flushing.
- The forces induced by pulsation can cause deflection of electrodes with a small cross-section, resulting in unanticipated size and/or positioning errors.

❑ Orbiting

Orbiting is the introduction of relative planetary motion (in most cases by means of table motion controlled by the CNC) between the electrode and

Figure #18

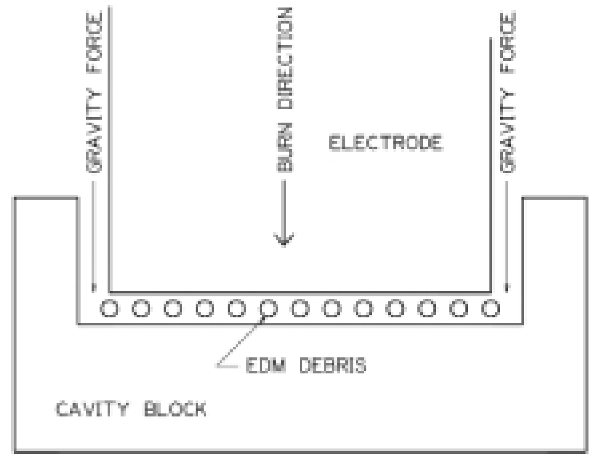

Figure #19

the workpiece in a plane perpendicular to the direction of the burn. The orbiting planetary motion is normally in the X-Y plane, but not necessarily so. The planetary motion effectively widens the gap on the side of the electrode that is not cutting, and induces dielectric flow which helps flush the gap. While orbiting does not result in the interruption of the burn, the electrode is only burning along a portion of its perimeter, thereby causing a reduction in effective burn rate, compared to sparking over its entire active surface in a Positive Flushing burn. Orbiting is often used in combination with Splash Flushing and Pulsation.

❑ Rotation

Electrode rotation (by means of either the C-axis or a rotating spindle) can also be utilized to generate relative motion between electrode and workpiece, for jobs involving the use of cylindrical electrodes. The hydrodynamic effect of the rotating electrode "drags" dielectric along its rotating perimeter. Rotation also offers the added benefits of even electrode wear, precise cavity location, and roundness generated by the spindle bearings.

❑ Vibration

Many years ago, vibrators were employed to enhance the flushing of cavity burns. The vibrator that I'm referring to is called a Metem Uniaxial Vibrating Table. ***(See Fig #18)***. A Metem Vibrator consists of a work table mounted mechanism containing a guideway and an AC coil. AC current flows through the coil, inducing a small vertical motion of the table surface with a frequency of 60 HZ. This vertical motion causes a "pumping" of the dielectric into and out of the gap, with minimal lost time due to pulsation interference with the sparking process. This method may not be effective with more sophisticated Sinker EDMs whose highly sensitive servos may follow the vertical motion of the vibrator, negating any flushing enhancement. Some of the earlier generation sinkers attempted to mimic a vibrator by applying a 60HZ signal to the Z-Axis servo, which often resulted in degraded servo response. Vibrators were especially useful in shallow production burns, but are seldom utilized today.

✓ The Effects of Gravity on Flushing

Many EDMers assume that electrodes must always be mounted on the Ram of the machine, and that EDMing must always occur in the Z minus direction. This traditional view of the EDM process is subject to the effect of gravity upon the EDM debris. ***(See Fig #19)*** Gravity tends to settle the debris at the bottom of the cavity, resisting

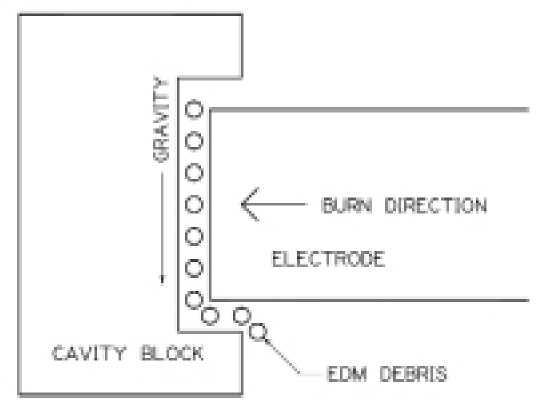

Figure #20

efforts to remove it. While the effect may be subtle, the results are significant, tending to trap the debris in the cavity. Burning through this trapped sludge can be problematic in terms of both productivity and quality.

I'd like to suggest that EDMers take a page from the milling machinist's play book and consider burning horizontally. ***(See Fig #20)*** Just as machinists discovered that chip evacuation is greatly improved on a horizontal machining center, so is EDM debris evacuation in a horizontal burn. With the advent of sophisticated Sinker EDM CNC controls, both burning, pulsation, and orbiting are readily accomplished in the horizontal mode.

✓ Conclusion

Careful consideration of flushing possibilities during the planning stage of any Sinker EDM job will pay significant dividends. For unlike the layman, we in EDM know that there is a lot more to flushing than what goes on behind the men's room door.

Any suggestions for future topics are welcome. Tell us what you would like to read about.

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- **IMTS 2008 Highlights — a "Toolmaker's" View**
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- **Safe & GREEN EDMing —** ***In contrast to many of the chip-making manufacturing processes, EDM is considered to have a low incidence of operator injuries combined with a minimal impact on the environment. This article will explore both the safety and environmental aspects of EDM.***
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