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Three EDM advancements spur productivity.

Charmilles Technologies

Automatic slug-removal systems facilitate lights-out machining.

Sparking Innovations

▸ BY E. "BUD" GUITRAU

You know the feeling: The week after you purchase a PC, a newer, faster CPU renders your "Buck Rogers" computer as obsolete as the comic book character. Advancements in electrical discharge machining don't occur at the same pace as computer developments, but progress is steady and ongoing.

Three of the latest EDMing innovations are described in the following pages. And although they won't render your EDM obsolete immediately, it might be wise to consider how these developments could "date" your equipment in the near future.

Flat Out Fast

Linear motors have been installed in a wide array of precision component-handling, inspection and vision systems. They also have found their way into CNC milling and turning machines, helping to send chips flying at feed rates of up to 2,400 ipm. And, recently, EDM builders began to incorporate this type of drive system into their equipment.

A linear motor is a round magnetic motor that has been sliced to the center and then rolled out flat (Figure 1). In a conventional motor, the magnets are arranged radially around an armature. A linear motor incorporates a coil assembly—a *flat* armature—that is fitted into the Z-axis ram and the machine table's X and Y axes. Powerful rare-earth magnets are positioned in alternating polarity in a steel or ceramic frame within the slide base or machine bed.

A linear motor operates much like a conventional motor in that it electromagnetically pushes and pulls a rotor. It's just flat instead of round, so it directly generates linear, rather than rotary, motion. *(For a more detailed explanation of linear motor construction, see CTE's August issue, page 86—Ed.)*

A linear motor augments the EDMing process in several ways. Primarily, it speeds up the machine's servo response. The better the servo response, the better the overall performance of the EDM.

Conventional EDMs must convert rotary motion into linear motion via belts, gearboxes and ballscrews. All of these conversions introduce mass, inertia, backlash, lag time, overshoot, friction and heat. Even with direct-drive systems (where the motor shaft is mounted directly to the ballscrew), the motor must first overcome the mass, inertia and friction of the ballscrew mechanism before it encounters the mass, inertia and friction of the table and the workpiece. Stopping this motion requires the same amount of time and energy.

Because a linear motor already provides linear mechanical motion, the need for power-transfer mechanisms is eliminated. And a linear motor's small, low-speed torque isn't an issue, because EDMs don't have the high-torque, high-load requirements of their chip-cutting cousins.

To better understand the technology, consider a CNC sinker equipped with linear motors. Compared to a sinker with conventional drives, it can advance and retract its axes quicker and more accurately. This reduces machining time while providing an improved, uniform surface finish.

It also means the potential for DC arcing is reduced. This undesirable condition occurs when the thousands of uniform sparks that vaporize and erode the workpiece material become channeled and focused on a single small area instead of being randomly discharged across the entire spark gap. The high concentration of heat and current can quickly damage both the part and electrode. Aptly called "EDM meltdown," it is usually caused by gap contamination, which is a result of poor flushing, insufficient off time or both.

The increased speed derived from a linear motor improves flushing of the eroded material. The high-speed retraction of the electrode creates a strong vacuum effect within the cavity, which is especially useful when machining parts with deep ribs. This enhanced vacuum pulls cool, clean dielectric oil into the low-pressure void left by the retracting electrode. And the superfast return stroke of the Z-axis forces the now-contaminated oil from the cavity. (The electrode also returns to the cut sooner, which boosts the metal-removal rate.)

Most EDM users believe that constant flushing is essential to effective machining. But some in the industry contend that flushing can be significantly reduced or eliminated with linear motors. Among them is P.J. Naughton, the marketing manager for Sodick Inc., Mount Prospect, Ill.

He said that flushing isn't as big an issue as it once was—even when EDMing rib cavities deeper than 1½". "The linear motor delivers faster jumps and reacts instantly to minute spark-gap changes to eliminate flushing in extremely complex dies and molds," he said.

"This motor provides ultrafast response time at speeds of 1,440 ipm, with a resolution of 0.000004"," Naughton added. And it has "fewer parts to wear out and won't slow down over time like most other motors. A linear motor also produces less vibration and provides more rigidity for smooth, quiet and reliable EDM production."

The advantages linear motors offer sinkers also apply to wire EDMs. The faster servo response and increased sensitivity they supply result in fewer wirebreaks—and the related downtime for rethreading—quicker and more accurate wire alignments, faster speeds and touch-off routines, better finishes, and the machining of crisper, sharper part geometries and details.

However, when it comes to equipping machine tools with linear motors, there are two issues that must be addressed. The first is heat. Flat or round, all motors produce heat. And fast motors produce it more quickly than slow ones. Heat causes machine components to expand, which can degrade the machine's ability to produce accurate parts.

With a conventional EDM, motors are usually mounted at the ends of the axes and exposed to the open air. Some motors are enclosed; they must be cooled. A simple fan usually will do the job.

A linear motor, though, is housed within the driven axis. Therefore, provisions must be made for heat removal. Sodick, for example, cools its linear-motor sinker machine with dielectric oil contained in a separate reservoir. The oil passes through the machine's chiller and then cools the motor's components. (Since wire machines do not travel at high axis speeds, less heat is generated, so they don't need cooling jackets.)

The second potential drawback to a linear-motor system is what can happen if there is a loss of power during operation. The heavy Z-axis of a sinker could come crashing down on top of the workpiece if the machine isn't equipped with built-in safeguards.

Counterweights and air-pressure systems create an axis-neutral buoyancy that removes most of the weight from the axes. And built-in electrical solenoids and safety interlocks ensure positive braking and locking in the event of power loss, loss of sensor feedback and/or control failure.

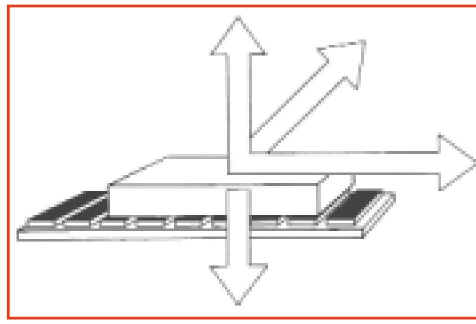


Figure 1: This schematic depicts the forces created by a linear motor. The direct transfer of magnetic flux to linear motion allows increased speed and accuracy when compared to traditional drives.

Don't Be Sluggish

An unwanted slug, or core of material left after wire cutting, represents a significant hurdle for unattended EDMing. When machining a die opening, the entire periphery is usually EDMed in a single pass. If the slug were freed as the wire cut into its original start hole, it could fall completely through the newly made opening and damage the lower nozzle, nick an insulated cable or get hung up on the lower arm.

Often, the slug becomes wedged in the opening and falls only part way through the Z-zero datum, located on the top of the worktable. If jammed solidly, the slug essentially becomes a part of the machine that the control knows nothing about, almost always resulting in part/machine interference or a catastrophic collision.

The traditional approach to handling slugs is to wire-cut in sections, leaving strategically located tabs—known as wire joints—to hold the part or slug in place. During the day, the operator can use shims, magnets or a high-strength glue to keep the slug-to-be in place. The operator then cuts the remaining tab, stops the machine and retrieves the part or slug.

For unattended operations, parts are cut and finished in rows but remain suspended by their cutoff tab(s). When attended machining resumes, the operator executes a simple cutoff routine after removing each slug or part. Some of today's faster machines allow small details—those under a ¼" square—to be "pocketed out." Doing this eliminates the slug altogether, but it only works with small details EDMed on fast machines.

A different approach is necessary for larger slugs, though, if unattended EDMing is to occur.

Automatic slug removal was introduced several years ago, but the technology never really caught on. That's changing, though, perhaps due to U.S. manufacturing's interest in automation and efficiency.

A number of EDM builders offer automatic slug-removal systems. Gisbert Ledvon, marketing manager for Charmilles Technologies Corp., Lincolnshire, Ill., explained how his company's EJECT 1000 system works (see article's opening photograph). The system generates a special "triangular" entry cut, wherein the wire is inclined so that the bottom of the cut is wider than the top. Upon completion of the entry cut, the detail is EDMed as it would be normally. For the last segment of the cut, the wire is once again inclined.

A hammer mechanism that has been positioned over the slug-to-be comes down when the cut is completed. “This fractures the strategically designed and placed triangular tabs and the slug falls through the plate,” said Ledvon. “The hammer passes completely through the workpiece to ensure that the slug has been fully ejected. The machine won’t move to the next position if the control does not receive the final eject position of the hammer. This ensures total machine safety.”

An 0.8"-dia. slug, measuring 4.7" high and weighing 2.2 lbs., can be cut and removed in about 40 seconds. Larger slugs, which require more tabs, can be automatically removed by executing a macro that’s resident in Charmilles’ EDM software, said Ledvon.

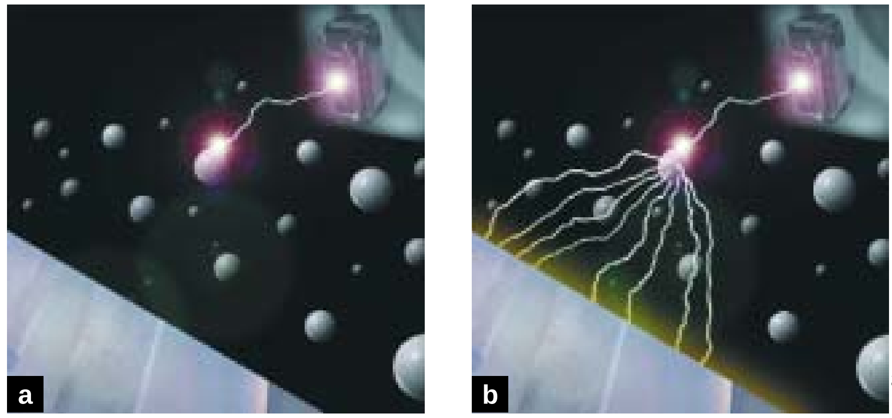
The benefits of EDMing with automated slug control can be dramatic.

Time Savings (hours)

Operation	Manual	Automatic
Roughing	7	8
Idle Time	7	0
Slug Removal	1	0
Finishing	3	3
TOTAL	**18**	**11**

Table 1: Manual vs. Automatic Slug Removal

Let’s say it’s 5 p.m. at a single-shift shop. The operator of a wire machine without auto-slug removal prepares to leave for the day. He sets his machine to cut a die opening that will take seven hours to rough, meaning the operation will be completed at midnight. At that time, the machine control reads a stop command in the program and waits, and waits, and waits. At 7 a.m., a full seven hours later, the operator returns to manually cut and remove the slug(s).



Makino Inc.

Figure 2a, b: Diffused-discharge machining is accomplished with a powder-mixed dielectric oil that allows the traditional EDM spark (a) to be diffused into smaller sparks, creating smaller craters in the workpiece (b). This translates to a finer finish than is possible with traditional EDMing. Since the same amount of total energy is applied to the workpiece, the metal-removal rate remains unchanged.

He restarts the machine to execute the finishing cycle and then completes the part about three hours later.

If you allow an hour for the manual slug-removal operation, the total run time is 18 hours. The same machine equipped with automated slug removal would save seven hours of idle time, plus the hour to manually remove the slug (Table 1). This significantly enhances the shop’s ability to make money by eliminating wait time and nonvalue-added manual labor.

Additive Value

Today, most mainstream dielectric fluids have the necessary characteristics to support efficient EDMing. And although improvements to these fluids have been ongoing, few of the earlier advancements they have undergone can compare to the new additive-based dielectric products that facilitate what is known as “diffused-discharge machining.”

DDMing involves mixing powder additives, such as silicone, chrome or graphite, with the dielectric fluid to “diffuse” or break up the spark into several smaller sparks (Figure 2). This action imparts a much finer workpiece finish than was previously possible.

To illustrate, consider a 5-amp spark that is broken into five 1-amp sparks, each producing a 1-amp-sized crater. Since the five 1-amp craters approximate the same volume as the single 5-amp crater, there is no loss in machining speed. Since smaller sparks also mean smaller craters, finer finishes can be obtained without diminishing the metal-removal rate.

According to Mark Rentschler, marketing manager at Makino Inc., Mason, Ohio, a powder-additive dielectric delivers dramatically improved surface finishes—down to 2 µin.—while increasing machining stability. He added that DDM fluids also can reduce polishing times by as much as 50 percent. This is especially attractive to moldmakers and others who have to finish ribs and other hard-to-polish shapes.

Developments like DDM, as well as the advent of linear motors and auto-slug removal systems, help to keep EDMing the oldest “emerging technology” in the metalworking industry.

About the Author

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