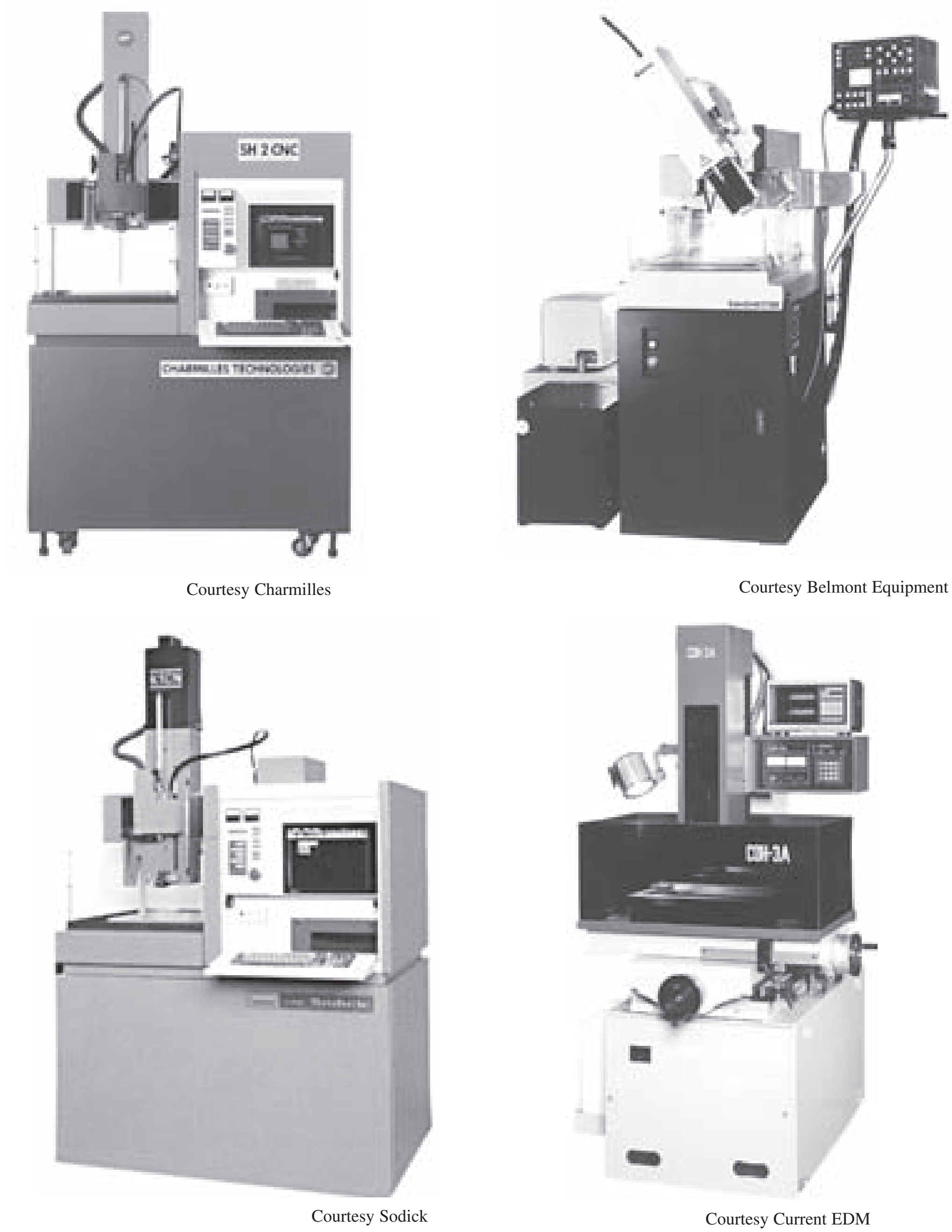
14 Small Hole EDM Drilling

Small hole EDM (electrical discharge machining) drilling, also known as fast hole EDM drilling, hole popper, and start hole EDM drilling, was once relegated to a “last resort” method of drilling holes. Now small hole EDM drilling is used for production work. Drilling speeds have been achieved of up to two inches per minute. Holes can be drilled in any electrical conductive material, whether hard or soft, including carbide. See Figure 14:1 for various small hole EDM machines.



Courtesy Charmilles

Courtesy Belmont Equipment

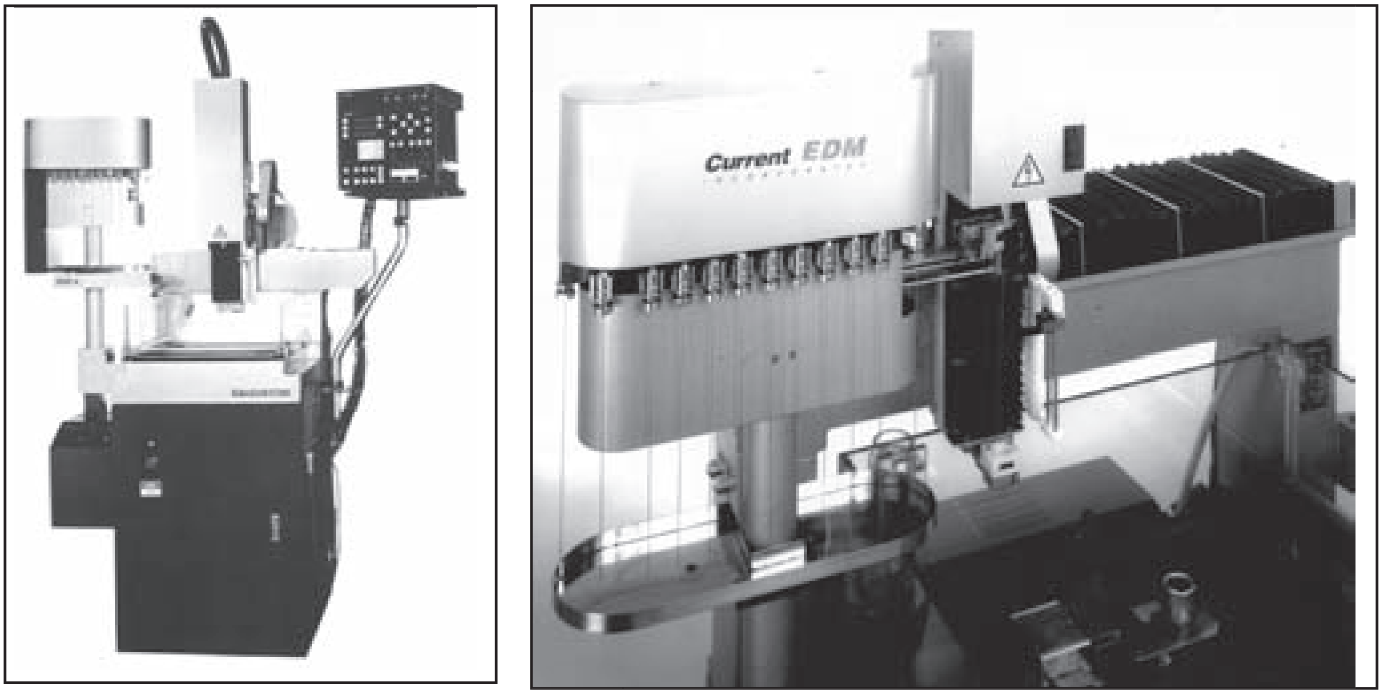
Courtesy Sodick

Courtesy Current EDM

Figure 14:1

Small Hole EDMs

For high-production small hole drilling, machines are also available with tool changers as illustrated in Figure 14:2.



Courtesy Current EDM

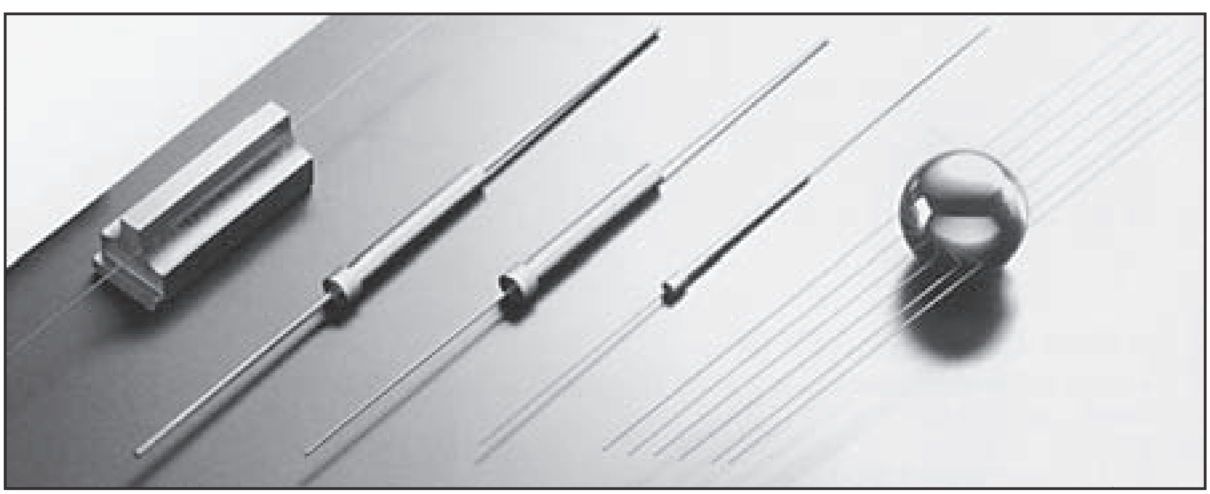
Courtesy Current EDM

Figure 14:2

Small Hole EDM with Tool Changer

Small hole EDM drilling is used for putting holes in turbine blades, fuel injectors, cutting tool coolant holes, hardened punch ejector holes, plastic mold vent holes, wire EDM starter holes, and other operations.

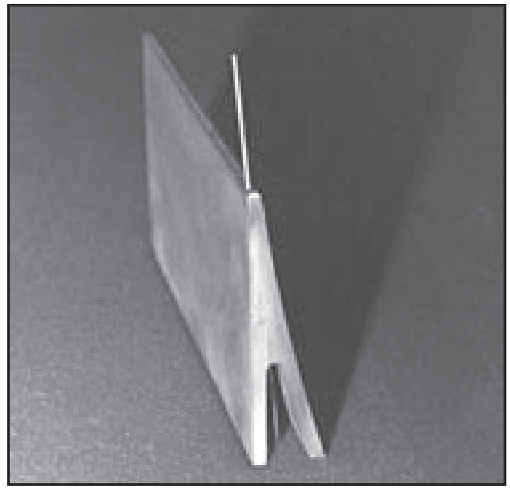
The term “small hole EDM drilling” is used because conventional ram EDM can also be used for drilling. However, ram EDM hole drilling is much slower than machines specifically designed for EDM drilling. See Figures 14:3 and 14:4.



Courtesy Belmont

Figure 14:3

EDMed Drilled Parts



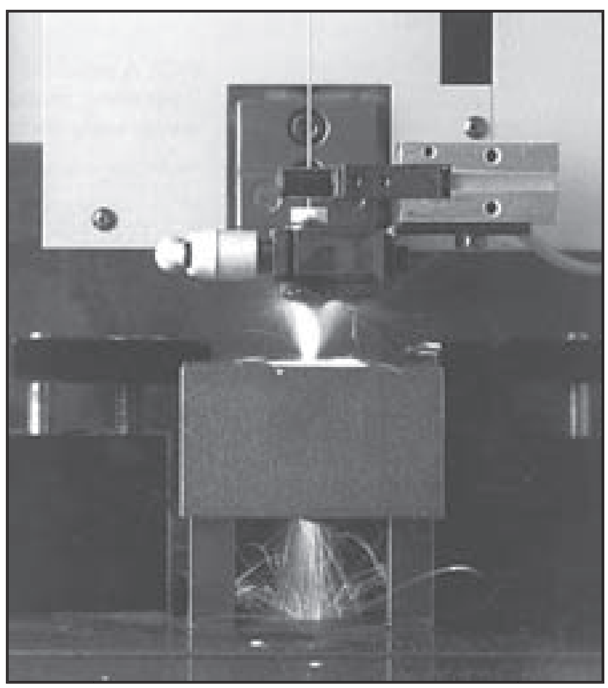
Courtesy Current EDM

Figure 14:4

Turbine Blade Drilled With EDM

How Small Hole EDM Drilling Works

Small hole EDM drilling, as illustrated in Figure 14:5, uses the same principles as ram EDM. A spark jumps across a gap and erodes the workpiece material. A servo drive maintains a gap between the electrode and the workpiece. If the electrode touches the workpiece, a short occurs. In such situations, the servo drive retracts the electrode. At that point the servo motor retraces its path and resumes the EDM process.



Courtesy Charmille

Figure 14:5

EDMing a Hole

A. Dielectric and Flushing Pressure

The dielectric fluid flushes the minute spherical chips eroded from the workpiece and the electrode. The dielectric fluid also provides an insulating medium between the electrode and the workpiece so that sufficient energy can be built. When the dielectric cannot resist the applied energy, a spark jumps from the electrode to the workpiece and causes the spark to erode the workpiece and the electrode. The servo mechanism provides the proper gap for spark erosion to continue.

Deionized water is preferred dialectic, but some manufacturers recommend an additive to aid in cutting. To accomplish small hole EDM drilling, high-pressure flushing is used (up to ten times the pressure for conventional ram EDM). Flushing pressure is one of the most important variables for high speed EDM drilling.

The dielectric should be clean. Some manufacturers use the dielectric only once; others reuse it. When the dielectric is reused, it should be filtered carefully to remove eroded particles.

B. The Electrode

A round hollow electrode is constantly rotated as the dielectric fluid is pumped through the electrode. The rotating electrode helps in producing concentricity, causing even wear, and helps in the flushing process. See Figures 14:6 and 14:7. Since the eroded particles are conductive, removing them from the hole is important to prevent shorting between the electrode and the workpiece, and to prevent EDMing the sides of the hole.

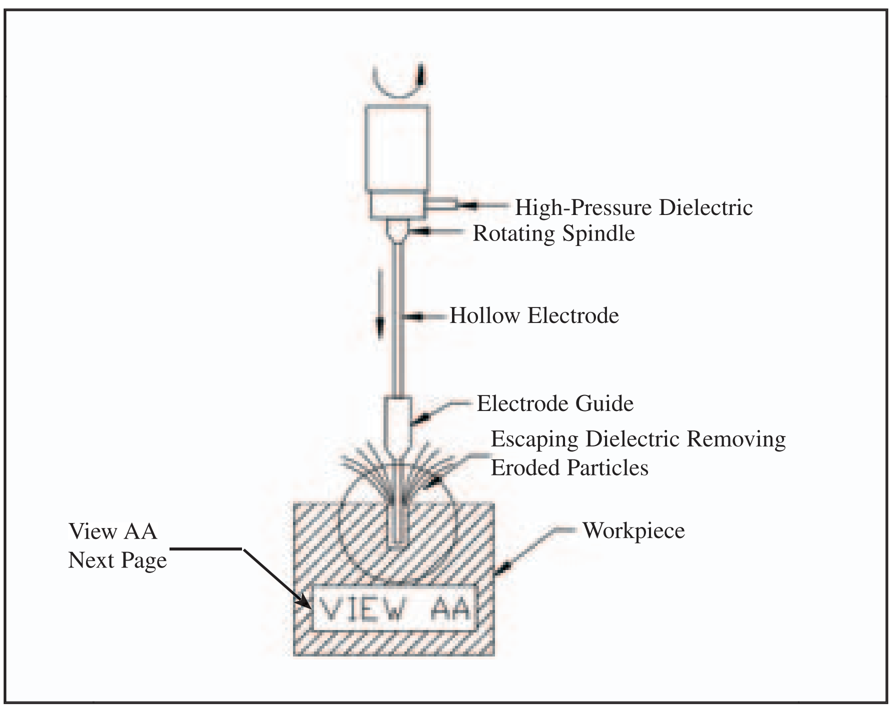


Figure 14:6

Small Hole EDM Drilling

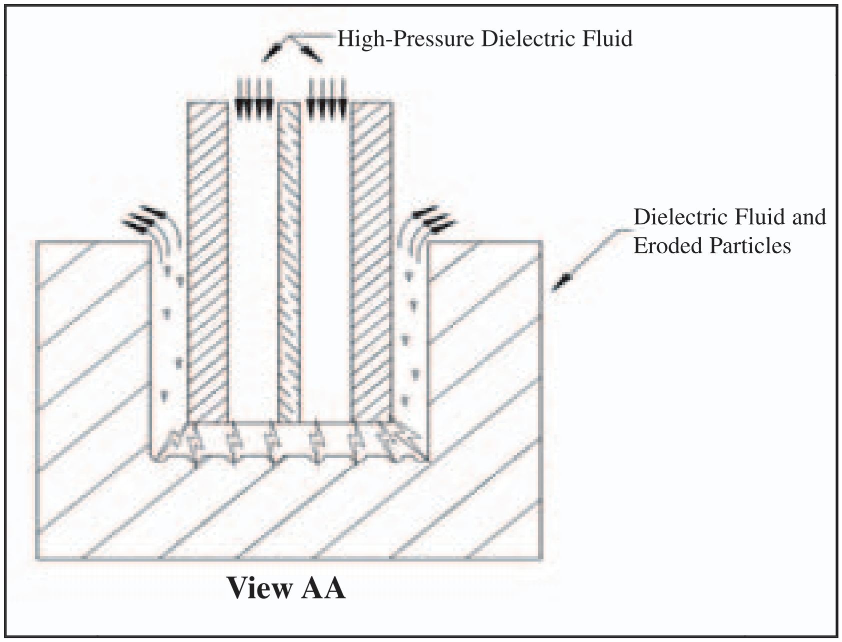


Figure 14:7

Rotating Electrode Eroding the Workpiece

The high flushing pressure through the center of the electrode tends to stiffen it. Also, the dielectric being forced out of the hole produces a centering effect upon the electrode. With the aid of the electrode guide and the flushing effects on the electrode, EDM drilling can penetrate much deeper than almost any other drilling method. Holes have been drilled up to 500 times the diameter of the electrode. At our company we have drilled holes 18" (450 mm) deep.

The high flushing pressure helps keep the workpiece and electrode cool. See Figure 14:8. This helps to keep the heat-affected zone, or depth of recast level, at a manageable level. The pressure also aids in producing a reasonably good finish. Regular ram EDM's, with weaker flushing pressures are unable to duplicate the results of small hole EDM machining.

Hollow electrodes allow dielectric fluid to flow through the electrode center. However, larger electrodes with a single hole can create problems. As the electrode erodes the workpiece, the center of the electrode

Figure 14:8

High flushing pressure helps to stiffen the electrode and keeps the workpiece cool.

does not remove material, thereby leaving a spike. The spike can cause the machine to short. A short causes the machine to retract, which lengthens the cutting time. To overcome this problem, electrodes with multiple channels were developed to eliminate center slugs, as shown in Figure 14:8.

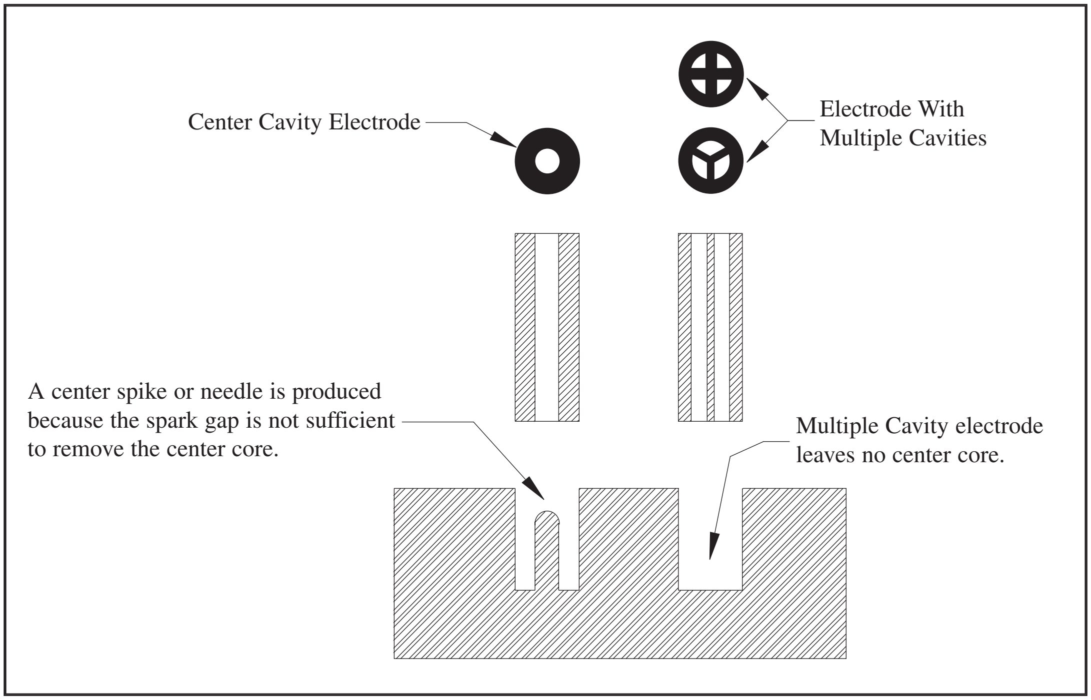


Figure 14:8

Various Tubular Electrodes and Their Results

C. Electrode Guides

The electrode guide keeps the electrode on location and prevents drifting while the rotating electrode is cutting. The electrode guide prevents electrode wobbling and aids in minimizing the EDM overcut, generally .001 to .002″ (.025 to .05 mm) per side. The guides are above the workpiece, this allows the high pressure dielectric to escape from the hole.

D. Servo Motors

The servo motors are controlled by a microprocessor which measures the gap voltage. By monitoring the gap voltage, the servo motor maintains the proper gap for spark erosion. If the gap voltage is too high, as in a short or accumulation of debris, the microprocessor signals the servo motor to retract the electrode. When the gap voltage is reduced, the servo motor advances the electrode and resumes cutting.

Due to the high-pressure removal of the EDM chips, the servo motor needs no constant retract cycle as in conventional ram EDM. The constant forward motion allows for rapid EDMing of holes.

Metal Disintegrating Machines Compared to Small Hole EDM Drilling

Metal disintegrating machines use the same principles as EDM, but these machines are used primarily for removing various types of broken taps, drills, and fasteners. Small hole EDM drilling is a much more precise method for drilling.

A metal disintegrating machine uses a hollow electrode to erode broken tools or fasteners. A coolant flows through the electrode and flushes the metal particles. Since the surface finish is unimportant, these metal disintegrating machines can remove within 1 minute a broken 1/4″ (6 mm) tap that is 1″ (25 mm) in the workpiece, and within 2 minutes a 1/2″ (13 mm) tap that is 1″ (25 mm) in the workpiece. These machines also come in portable models and can cut upside down.

Other Methods to Produce Holes

Besides small hole drilling, ram EDM, lasers, and photochemical machines can produce holes, even into hardened materials. Conventional drilling machines using carbide drills can also drill many hardened materials.

Disadvantages in Small Hole EDM Drilling

A. Electrode Wear

Considerable electrode wear results from EDM drilling. The electrode wear can equal or exceed the depth of the hole. For example, a two inch (51 mm) depth can wear the electrode two inches (51 mm) or more.

B. Reduced Speed for Large Holes

Although large holes can be EDMed, the drilling time is often not competitive with conventional drilling or with wire EDM. For some difficult drilling applications, like carbide, a starter hole can be drilled with small hole EDM and then machined with wire EDM. Small hole EDMing is also used for holes that cannot be deburred due to obstructions.

C. Blind Holes are Difficult to Control

Due to the high electrode wear, the depth of blind holes is difficult to control. Whenever possible, conventional drilling should be used for blind holes.

However, if a blind hole is needed, the electrode needs to be dressed or a new electrode used. Otherwise, electrode wear causes a bullet-shaped hole at the bottom.

Advantages in EDM Drilling

A. Drilling on Curved and Angled Surfaces

When holes must be drilled on curved or angled surfaces, great difficulties arise with conventional drilling. Drills tend to walk off such surfaces. To prevent drills from walking, fixturing and guide bushings are used on these irregular surfaces to guide conventional drills. But in EDM drilling, the electrode never contacts the material being cut. This non-contact machining process eliminates the tool pressure when drilling on curved or angled surfaces; however, water pressure coming from the electrode can cause slight deviation on curved surfaces. In starting, use lower water pressure to prevent water pressure movement of the electrode. See Figure 14:9.

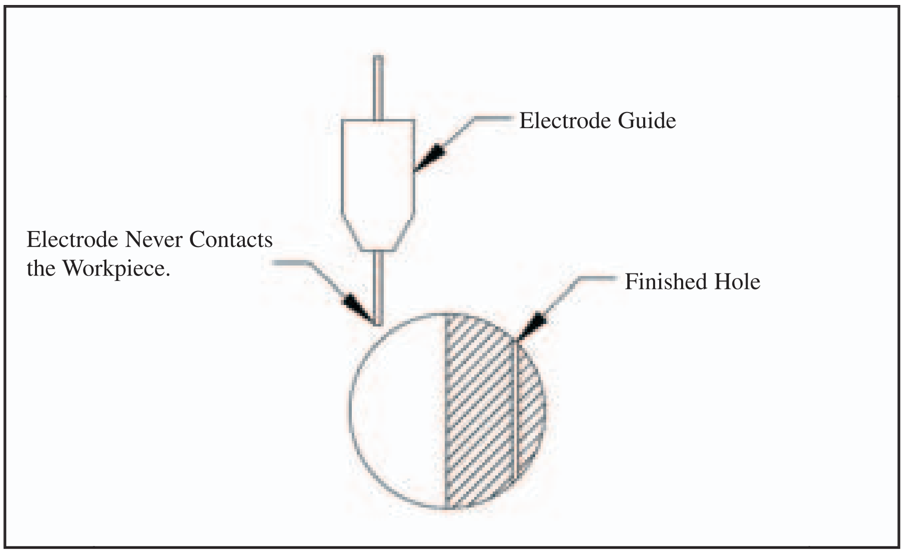


Figure 14:9

Non-contact machining allows electrode to enter curved and angled surfaces.

B. Drilling Hardened Materials

Some materials are too hard to drill using conventional methods, i.e., hardened tool steel, difficult alloys, and carbide. But material hardness does not affect the EDM process. However, some materials, like carbide, cut slower, not because of hardness, but because of conductivity properties of carbide.

C. Materials That Produce Chips that Cling to Cutters

Materials such as soft aluminum and copper can produce chips that cling to cutters. EDM drilling easily machines such materials.

D. Drilling Deep Holes

Drilling deep small holes with conventional drilling is often extremely difficult, and many times impossible. Small EDM hole drilling is often the only practical method for producing such holes.

E. No Hole Deburring

Deburring of holes from conventional drilling can take longer than drilling the holes. As in conventional EDMing, small hole EDM drilling creates no burrs when drilling. See Figure 14:10. This burr-free drilling is especially important when difficult holes, such as turbine blades, require deburring.

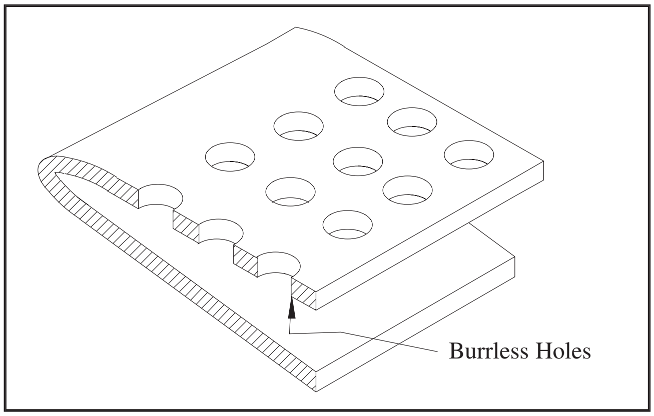


Figure 14:10

Difficult to Deburr Holes

F. Preventing Broken Drills

As conventional drills enter or exit curved or angled surfaces, they tend to break if not carefully controlled. Small broken drills are also often extremely difficult to remove from the workpiece. To prevent breaking drills in conventional drilling, controlling torque conditions are critical. However, in EDM drilling the torque conditions do not exist since the electrode never contacts the workpiece.

G. Creating Straight Holes

Due to the non-contact process of EDM, the deep hole EDM drilling produces straight holes. In contrast, conventional deep hole drills tend to drift.

Accuracy of Small Hole EDM Drilling

Because eroded particles from the holes are flushed, variations can occur in the hole diameter. These are the reported results of small hole EDM drilling with a .040″ (1 mm) drill in D2 tool steel.

Depth	Straightness	Taper
1″ (25.4 mm)	+/-.0003″ (.0076 mm)	+/-.0005-.001″ (.013-.025 mm)
4″ (102 mm)	+/-.001-.0015″ (.025-.038mm)	+/-.0025-.004″ (.064-.102 mm)
8″ (203 mm)	+/-.0015-.004″ (.038-.102 mm)	+/-.005″ (.127 mm)

Versatility of Small Hole EDM Drilling

At Reliable EDM, we purchased a small hole EDM drilling unit that could be mounted on a milling machine to obtain greater versatility. This enabled us to EDM large workpieces. See Figure 14:11.

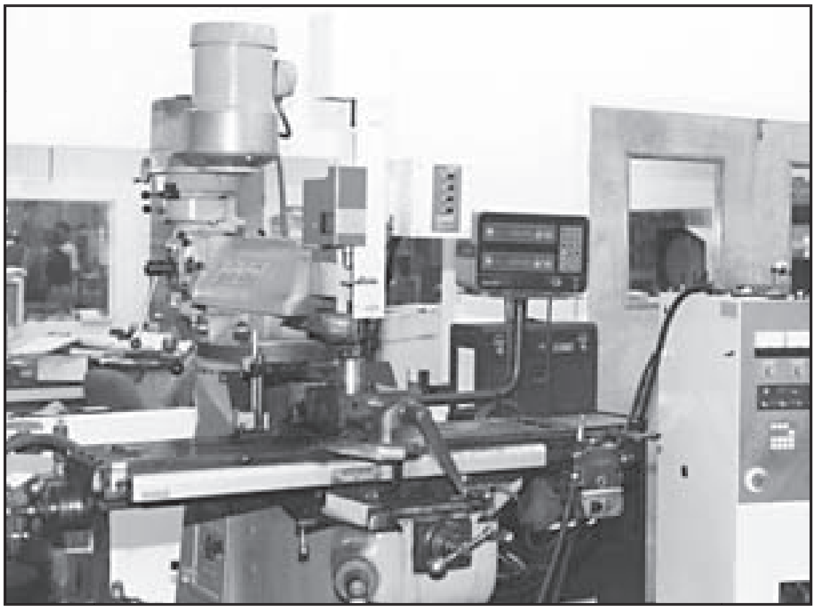


Figure 14:11

Small Hole EDM Drill Mounted on a Milling Machine

Our company also has a CNC small hole EDM. With this machine we were able to drill 1,800 .020" (.51 mm) holes. See Figure 14:12 and 13.

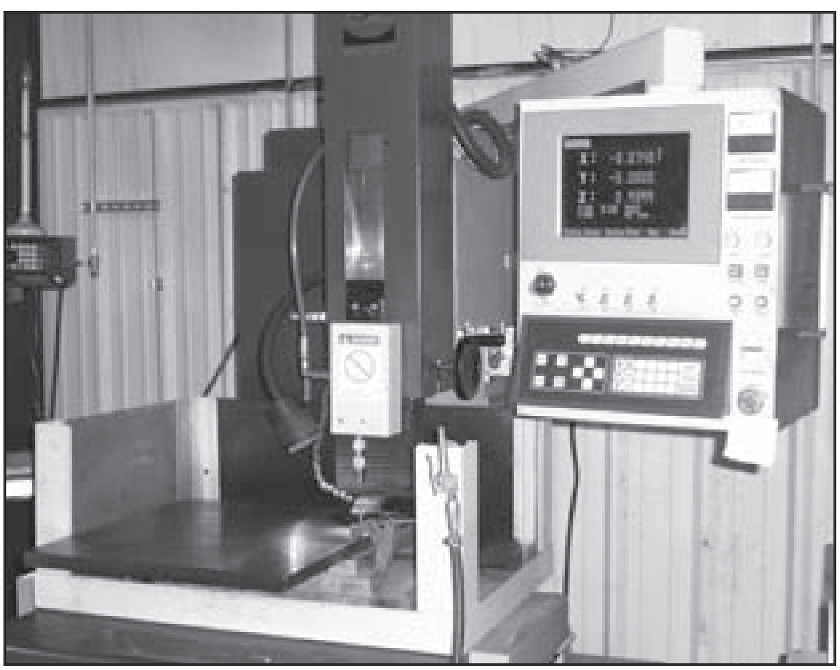


Figure 14:12

CNC Small Hole EDM Drill

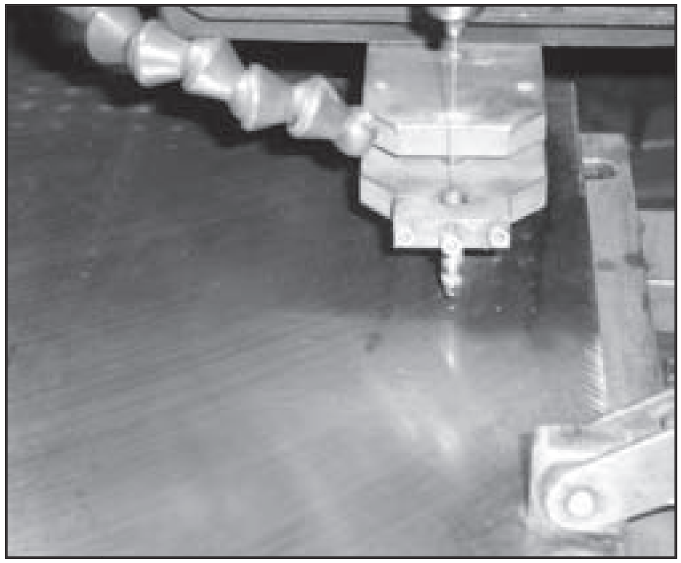


Figure 14:13

EDMed 1,800 .020" (.51 mm) holes

Conclusion

Small hole EDM drilling has many applications. It is an extremely cost effective method for producing fast and accurate holes into all sorts of conductive metals, whether hard or soft.