Precision Electrolytic Machining

By Donald G. Risko

PEM Technologies presents precision electrolytic machining, a stress-free process that removes metal from the surface atom by atom.

Engineers and manufacturers looking to create gears with high tolerance, precision, and a smooth surface finish have a new technology to consider: Precision Electrolytic Machining (PEM). This niche process is now being launched in the United States, affording companies the ability to address a variety of manufacturing efficiencies in specific areas.

For many years electrochemical machining has been used in automotive, aerospace, and medical manufacturing for machining components to tolerances of a few thousands of an inch. Electrolytic machining is based on the Faraday principle of electrolysis. This machining process is often characterized as "reverse electroplating" in that it removes material instead of adding it. Metal removal is achieved by electrolytic dissolution of a metal surface connected to the negative polarity of a DC power source in an electrolytic cell. The cathode (tool) determines where material is removed from the anode (workpiece) by proximity of the tool to the workpiece.

The anode metal dissolves electrolytically, and its rate of dissolution depends only upon the atomic weight and the ionic charge, the current that is passed, and the time for which the current passes, which is Faraday's Law. The dissolution rate is not influenced by the hardness or other characteristics of the metal. Since only a small amount of hydrogen is evolved at the cathode, the shape of the electrode remains unaltered during the electrolysis. Therefore, material removal is principally determined by current and time.

The PEM process is an advancement of electrochemical machining that incorporates pulse power and an oscillating cathode tool that can machine even hard metals to less than a thousandth of an inch. This innovative machining concept advances a cathode (tool) into an anode (workpiece), pulses the metal removal current while in close proximity (typically 10 to 20 micron gap), then retracts. As electrons cross the gap during the pulse, material on the workpiece is dissolved as the tool forms the desired shape. Pressurized electrolyte is injected at a set temperature while the gap between tool and workpiece is open to flush away the metal hydroxide formed in the process. Precise shapes such as gear teeth with excellent surface finish can be created with the PEM process. For example, four gears—like the stainless steel gear in fig. 1—can be machined simultaneously to final form and surface finish. Typical machining rates are .04 to .05 inch per minute.

ONE MACHINE, MULTIPLE GEAR TEETH

With PEM it is possible to manufacture OD, ID, and linear gear teeth machined on the same machine with a simple change of tooling. The PEM process uses pre-machined electrodes to machine gear teeth. These electrodes are not consumed in the machining process; therefore a long tool life is characteristic of the PEM process. A unique example is shown in fig. 2. A thin plate electrode made via EDM was used to machine an ID gear. A thin section was cut from the ID gear and subsequently used as an electrode to PEM machine an OD gear. Internal machining capability of the PEM process is another characteristic that can be used to reliably create features that are either difficult or impossible to create with conventional machining methods. Since the PEM process machines without mechanical forces and produces excellent surface finish, stress free

features that do not exhibit micro cracks or metallurgical defects are produced efficiently and reliably. An example of internal machining is a diesel fuel injection component that requires an oval cavity in the sidewall of the fuel feed bore.

The sectioned housing shows the internal feature created and the PEM electrode in the machining position. In fig. 3 a dual PEM electrode used to machine two housings is shown. The part fixture slides the housing over each electrode to the machining position, and 24 dual cathodes machine 48 parts simultaneously. Linear features, such as those of the linear bearing (see fig. 4), are PEM machined in components up to a meter in length. In this case both large and small features are machined in the linear bearing to precise tolerance.

EXCELLENT SURFACE FINISH AND NO BURRS

Since the PEM process is a stress-free metal removal process that removes metal from the surface atom by atom, there is no possibility of forming burrs or mechanical deformation at the edges. High quality gears can be machined without the concern for burrs being introduced into the final product. Gears for precision meters are machined burr-free, six at a time, in a standard PEMTec machine. Although surface finish is material dependent, many materials are machined to very smooth finishes, with some as good as 1-4 in Ra.

PEM IS FULL FORM MACHINING

PEM machining is a full form precision machining process that removes material as an area machining process. Therefore, machining usually starts with a solid blank or a preform of the component geometry. The electrode used to machine the turbine wheels is also shown in the figure. The electrode is a negative of the turbine wheel geometry less the machining gap for electrolyte. Eight turbine wheels are machined in one 45-minute machining cycle.

Punch dies are another example of an application of the PEM machining process Hardened punch blanks can be machined to final form and surface finish for a variety of shapes.

A STORY OF INNOVATION

For more than a decade PEM Technologies has been recognized in Europe for the extreme precision, easy handling, and flexible applications

Fig. 1: A stainless steel gear.

of its machinery in the manufacturing process. The company invested in the R&D necessary to advance the concepts originally proposed by scientists. Once the process had been mastered, PEMTec worked to establish a customer base and product acceptance in Europe before expanding globally.

The company is headquartered in Forbach, France, and is known as PEMTec in Europe. However, the company will operate under the name PEM Technologies in the United States. PEM Technologies is an engineering company whose entire focus is on developing and manufacturing machinery for precision electrochemical machining used in metalworking.

From its inception in 1995 the company has

Fig. 2: A thin-plate electrode was used to machine an ID gear.

PEM MACHINING CENTER/IMTS

To be unveiled at IMTS booth #E-4428, the PEM Machining Center consists of four major components.

- **PEMMACHINE:** Precision electrolytic machine for the manufacturing of precise, full-form features in almost any metallic material. The process is specifically applicable for tempered steel and alloys that are difficult to machine by conventional methods. This robust processing machine is constructed out of granite and stainless steel and tolerances are held within micrometers.
- **PEMPOWER:** Pulse power source provides machining power that is synchronized with the oscillating head of the machine. This modular and dynamic direct current source delivers precision pulse power.
- **PEMAQUA:** Used for electrolyte processing and as a supply unit for the PEM Machine. The environmentally friendly automated electrolyte system provides micro-filtering with variable flow rate, and controlled pH, conductivity, and temperature control.
- **PEMCONTROL:** Precision control with the decentralized distributed intelligence to control the process and to regulate and monitor relevant PEM machining center functions. The PC-based system with touch screen interface provides for ease of operator input and graphical status display.

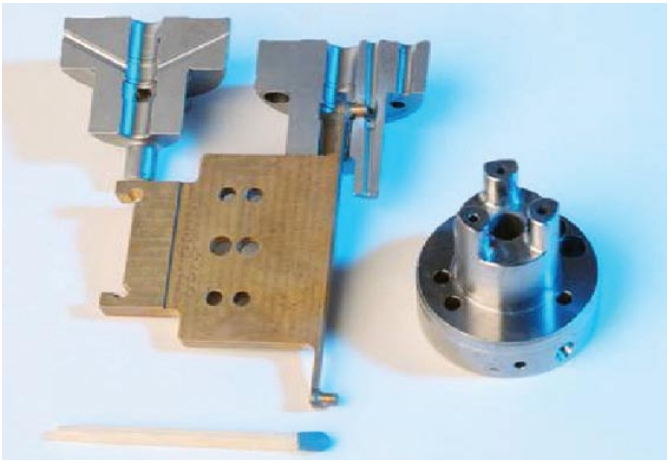

Fig. 3: A dual PEM electrode used to machine two housings.

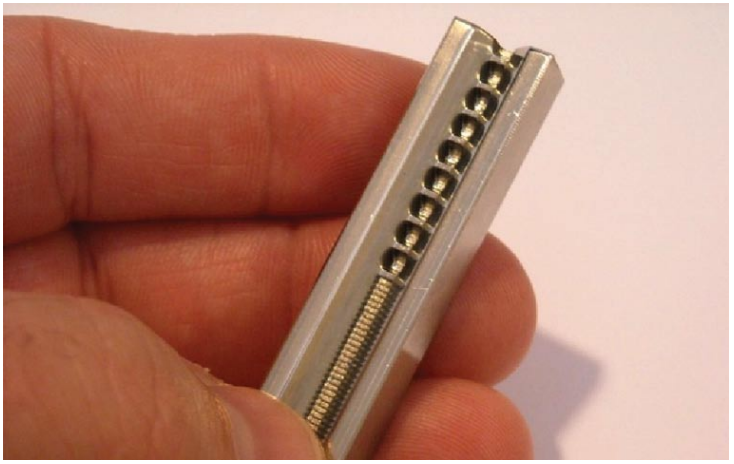

Fig. 4: PM-machined linear bearing features.

specialized in precision electro-chemical machinery. Electro-Chemical Machining (ECM) is a process in which metal is machined through the use of electricity and chemistry to quickly and accurately erode and produce the desired end product. This process is widely applied for polishing metal surfaces, deburring, and cavity-sinking metal components. The basis for today's machinery is formed by tried and tested ECM technology, which was first applied in industrial manufacturing several decades ago.

PEM Technologies' application development engineers are highly skilled in designing tooling to meet every customer's needs. PEM machines process serial parts in a wide variety of sectors such as the automobile industry, medical technology, aviation, and aerospace, tool and mold construction, machine engineering, gearbox technology, and many other industries.

ABOUT THE AUTHOR:

Donald G. Risko is vice president PEM Technologies, LLC. He can be reached at (412) 736-7961, or visit [www.pemtechnologies.com].