▶BY ALAN RICHTER, MANAGING EDITOR

A look at permanently marking metal parts with electro-chemical, indent or laser systems.

Cradle to Crypt

More and more parts are being marked for traceability, identification, authenticity-documentation and process-progression requirements. The marking tools and systems available to do the job almost seem as varied as the parts. The metal-marking methods range from a simple hammer-and-die approach to sophisticated laser etching.

Determining which marking tool to apply depends on a variety of parameters. These include—among others—workpiece material, part volume, part features, type of mark, cycle time, the part's operating environment and costs.

Coding with Stencils

Regardless of the industry the parts are for, most have to be marked, said Charlie Nichols, president of Marking Methods Inc. The Alhambra, Calif.-based company makes electro-chemical etching systems, which can apply a wide array of marks including machine-readable, 1-D and 2-D data-matrix codes. This type of bar code is scaleable and accepted by the Air Transport Association of America Inc.'s SPEC2000 for parts whose marking area is limited.

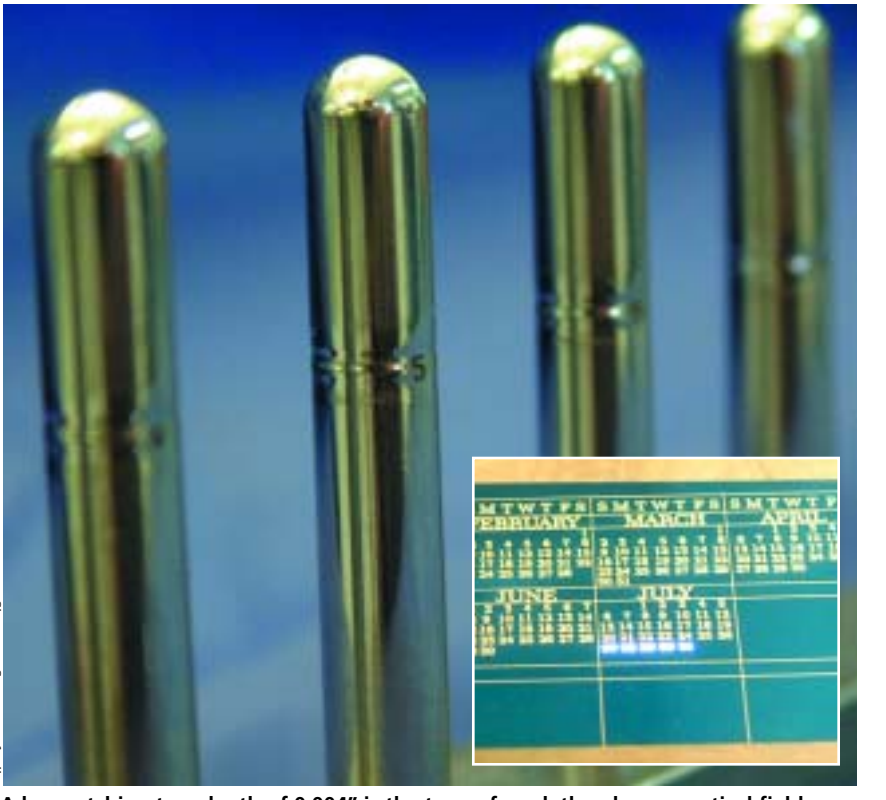
To code electro-chemically, Nichols explained that a resistor coating is transferred from the back of a stencil to the backing paper to create openings (the image) in the stencil. The stencil is then removed and placed on the part to be marked. When the marking applicator contacts the data-matrix pattern on the stencil, the current passes through the openings in the stencil and generates a permanent mark.

"It's like silk screening, but it uses a random-fiber, paper-based stencil instead," he added.

The process, which removes metal similar to electrical discharge machining and electro-chemical deburring, can permanently mark any electrically conductive metal part. "Generally, it can even mark on any coated, plated or treated surface," Nichols said, "as long as it's conductive."

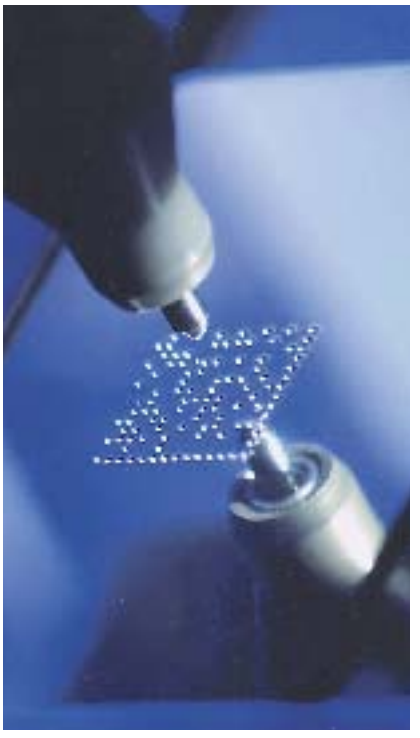
The marking depth range is from 0.0001" to 0.01", with the latter depth allowing part painting without obscuring the mark's visibility.

According to Nichols, marking the part induces little or no stress. This al-



Tiffany Privat/Begneaud Mfg.

A laser etching to a depth of 0.004" is the type of mark the pharmaceutical field uses for sequential numbering of capsules. Inset: A laser can also rapidly and clearly etch identical information into multiple workpieces.



Mecco Marking and Traceability

A computer-controlled marking head with a carbide stylus creates an information-rich, 2-D data-matrix code for product traceability.

lows etching of thin-wall features without damage, since alteration of the part's molecular structure doesn't go beyond the depth of the mark. "A steel stamp causes stress risers and damages the structural integrity," he added.

In addition to stencils, electro-chemical marking requires an electrolyte solution to carry the electrical current. The part is positioned on a grounded plate, which completes the circuit. "The electricity does the etching and not the solution," Nichols explained. "It's a reverse-plating process, pulling the metal off of the part as it's being etched."

Although an electro-chemical etching kit starts at about $1,000, the chemical solutions, as well as the pads and stencils, require replacement once depleted. Under normal use, a stencil is able to mark 20 to 50 times, Nichols said, while a stencil for deep etching might need to be replaced after each marking. He added that the cost per etch is about 1 to 3 cents.

With electro-chemical marking, workpiece hardness is not a factor. Conversely, he said a workpiece harder than 62 HRC will cause a dot-peen marking tip to shatter or flatten. "You have to dot-peen mark before heat treating, and you have to be careful with thin-wall features," Nichols said. "The rule of thumb is don't let the mark exceed 10 percent of the wall thickness."

Point into Part

A dot-peen system is another way to permanently mark parts with dot-matrix codes, serial numbers, date codes and other forms of identification. The electrically controlled units apply a carbide stylus to cold-form dots (spherical recesses) with low-stress, compressive force. The stylus generally has one of three tip angles: 60°, for deeper and narrower impressions; 90°, for mid-range indentations; or 120°, for wider and shallower dots.

The dot-peen method creates easy-to-read straight, arced or radial inscriptions in soft or hard materials and on flat or uneven surfaces, according to Bloomfield, Conn.-based Dapra Marking Systems. Rick Pentz, Dapra's general manager, maintained that indent marking can be performed on metals up to 65 HRC, imparting a mark that's only 0.0005" to 0.001" deep. But "tool life can be awful" when marking parts that hard, he noted.

A host of dot-peen systems are available, ranging from hand-held to benchtop to integrated stations for production lines and severe industrial conditions. Regardless of the type, Pentz said end users want turnkey systems. In addition, most incorporate robots to place parts in the marking station.

"You need to determine how parts can get into the dot-peen marking station," Pentz said. "It can be manual to semi-automated to fully automated."

Obviously, the price of a dot-peen system depends on its level of automation and sophistication. A low-end benchtop unit costs about $5,500 to $6,000 and a hand-held marker runs from $6,000 to $7,000, Pentz said, adding that modified software and material handling equipment can push the price tag to $30,000 or more.

According to John Beutell, product manager for Technifor Inc., Charlotte, N.C., the average price for a dot-peen marking system is $9,000 to $10,000. He noted that job shops tend to select benchtop systems with a variety of interchangeable fixtures and tooling, while contract manufacturers have systems integrated into their production lines with fixtures and tooling set in place.

To see that each part receives its intended mark, a camera-like mechanism can be added to the system. Beutell said this "closes the loop" to provide complete part traceability and greater throughput.

He added that the mechanism takes a picture of each part and analyzes the picture with software running in the

In-machine marking

To eliminate the need for a separate station or manual operation to mark machined parts, Macro Tool & Machine Co. Inc. developed the Siegel Promarker. Dan Siegel, president of the LaGrangeville, N.Y., company, explained that the tool functions like a dot-peen marker, except it's kept in a machining center's carousel and the marking is accomplished "in-process" via CNC programming. The tool is available in standard CAT and BT sizes and comes with a standard 1"-dia. straight shank. The unit converts the rotary movement of the spindle and translates it to the tool's vertical marking motion.

The formula for calculating the feed rate is:
Feed (ipm) = distance between dots (in.) x 4 (hits/rev.) x rpm.
"We use it in-house for marking aluminum parts and cold-rolled steel," Siegel said.

The price for the standard tool is $1,875.

Contact Macro Tool & Machine by calling (824) 223-3824.

background. The database stores the information about what is marked—not the image itself. For example, the software records what serial numbers were marked on a given day.

"The camera mechanism system can also recall a smaller segment, if needed," Beutell said. "For example, by narrowing down which parts were marked from which batch or from which production line."

Noncontact Marking

For those companies with the volume of marked parts to justify the $50,000 to $150,000 or higher price tag, a laser system is the route to go, said Tim Edwards, product manager for laser-marking systems, Trumpf Inc., Farmington, Conn. He estimated a daily volume of about 500 to 1,000 parts is required. The exception is aerospace tooling and fixtures, which are almost always suitable applications for laser marking, since their price tags are generally high.

Edwards added that while the upfront cost for laser-marking technology is higher than other types, once a system is purchased, the cost to mark is close to free, excluding maintenance. "A laser is the lowest-cost method for high-volume marking," he said.

In addition to parts, Edwards said laser marking of expensive specials helps manage and track the complex cutters. "You can put a unique mark on the tool and scan the tool with a digital camera to verify that you have the right tool for the job."

Don Begneaud, owner and president of Begneaud Mfg. Inc., said his Trumpf VectorMark laser marker functions as a complementary machine to provide his customers with one-stop shopping. The Lafayette, La., company etches a variety of metals, including aluminum, stainless steel, titanium and special-plated materials, with the Nd:YAG laser.

"I bought the machine before I had the work for it because I have a fascination with the technology," he explained. "I show my customers the machine and sell them on the service."

In one application, he said he was able to mark different names and numbers on about 1,000 tags using multiple pallet trays with six tags in each. The information was stored on a computer disk and read in real time, allowing him to mark a tray of tags in about 1 minute. He added that stainless tags take about 5 minutes per pallet.

Laser Selection

Although numerous types of lasers are available, Sam Yerardi, laser development engineer with Telesis Technologies Inc., said most industrial end users mark with neodymium-doped yttrium aluminum garnet lasers. "Nd:YAG lasers are the main workhorse for most industrial marking applications, but a significant number of marking applications are addressed by CO_2 as well as other wavelengths," he said.

Of the Nd:YAG lasers, Yerardi indicated the majority are lamp-pumped systems as opposed to diode-pumped, which is one of the newer technologies but is gaining market share.

One advantage of diode-pumped, solid-state lasers is they require less power. "Typically, the diode systems go up to about 50 watts continuous power, and the lamp systems go up to 100 watts CW," he said.

Another advantage is that diodes last significantly longer before needing replacement than a lamp. Yerardi indicated that a diode's life is measured in thousands of hours of operations, while a lamp typically provides 600 to 1,200 hours of operation, depending on operating parameters.

In addition to power requirements, the tradeoff is the cost of maintenance. "Depending on the type of diode-pump laser technology employed, the cost for replacing diodes can be significant," Yerardi said. "A lamp is around $200."

In comparing dot-peen to laser marking, Yerardi said a laser is able to mark with significantly less workpiece damage and, when required, no material surface deformation. "With the dot peen, the pin is always going to impact the surface and create a crater or displace material because of that impact," he said. "With the laser, you may want to actually vaporize material or cut into the material to make an engraved mark or you may just want to remove anodizing, for example, to create a legible, contrasting mark."

The following marking tool companies contributed to this article:

Dapra Marking Systems
(800) 442-6275
www.dapramarking.com

JDS Uniphase Corp.
(800) 254-3684
www.jdsu.com

Marking Methods Inc.
(626) 282-8823
www.markingmethods.com

Mecco Marking and Traceability
(888) 369-9199
www.meccomark.com

Technifor Inc.
(704) 525-5230
www.technifor.com

Telesis Technologies Inc.
(800) 654-5696
www.telesis.com

Trumpf Inc.
(860) 255-6011
www.vectormark.com

The following company also contributed to this article:

Begneaud Mfg. Inc.
(337) 237-5069
www.begno.com

Yerardi added that a laser can also anneal metal, a typical application with steel-base parts. "For example, Nd:YAG laser energy interacting properly with stainless steel can result in a very distinct, contrasting mark," he said.

Conversely, a pin-stamp machine is able to produce more readable results than a laser when marking a curved or irregular surface. This is because the laser's focal depth needs to be maintained at almost the same distance throughout the marking process to achieve the best results, while the dot-peen's pin-throw range can accommodate a greater surface variation. "The allowable distance is much greater in the pin-stamp world than in the laser world, where the focal-point range is much tighter," he said.

This difficulty in laser marking such surfaces can be overcome by using a fiber laser attached to a robot that fol-

lows a curve, for example, and maintains the proper focal distance. Since all of the components are fused together through the fiber, the laser is immune to misalignment and optical contamination, reports the Commercial Laser Div., JDS Uniphase Corp., San Jose, Calif. In addition, the company reports that there are no coupling losses or reduction in beam quality, since the fiber that connects the laser to the scanning head is the laser itself.

"The laser is easy to move, like moving a cord," said Ruediger Hack, the division product marketing manager.

JDS' fiber lasers are air-cooled, run off wall-socket electricity and are available as 9-, 15- and 25-watt industrial systems.

Hack said one industry JDS is targeting is medical, since fiber lasers are able to produce a permanent, clean mark by discoloring the surface without breaking it. "Engraving may break a metal surface, allowing bacteria to get in," he said.

Primarily, though, JDS sells the fiber-laser modules to OEMs that assemble the components into turnkey systems.