▶ BY GARY SHERIFF, SHERTEC

Marking Progress

CO_2, YAG and fiber lasers all provide a viable method for marking most materials and parts.

Part marking has always been necessary for identification purposes and is an essential part of today's ever-growing list of manufacturing requirements. Cost-cutting demands and recent marking regulations, such as SPEC2000 imposed by the Air Transport Association of America, continue to challenge the limitations of older, less-efficient marking methods.

Lasers offer a permanent and repeatable marking technique that can be effectively adapted to all marking demands. They can be integrated into the manufacturing flow without causing major disruptions to productivity and require little maintenance. The CO_2, Nd:YAG (neodymium: yttrium aluminum garnet; commonly abbreviated as YAG) and ytterbium fiber lasers account for almost all laser marking performed and can process almost any material.

Setup

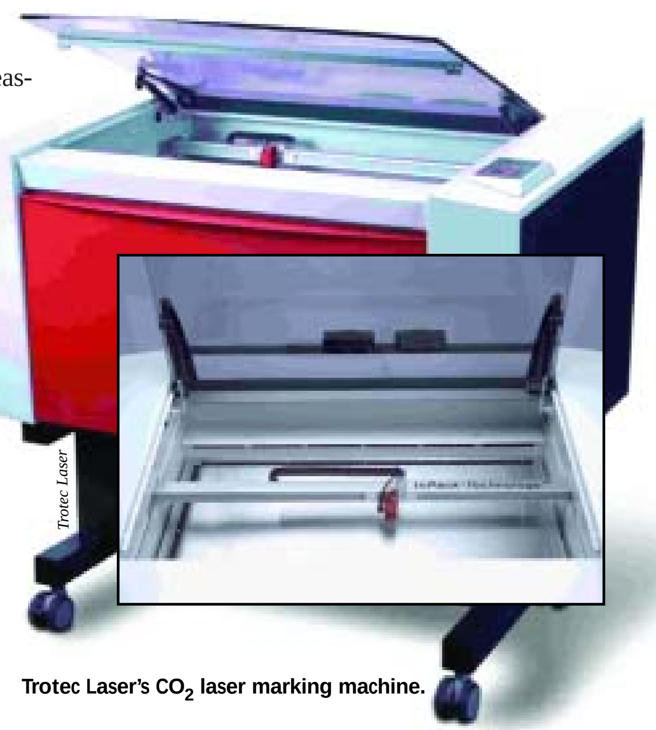
Lasers have been a viable method of marking, cutting and welding for approximately 30 years. Recently, with the adaptation of Windows-based software, laser marking has been an excellent method to provide a means for traceability, bar coding, serialization routines and even decoration.

The procedure is similar to printing a paper document from a computer, except instead of loading paper into a printer, parts are loaded into an enclosure. Most setup is done via the computer, thus reducing physical human intervention, which is, in most cases, time-consuming and a major cause of errors. The resulting marks are repeatable, allowing high yield ratios—typically approaching 100 percent.

Whether marking with a YAG, fiber or CO_2 laser, numerous file formats, including vector and bitmap, can be imported and manipulated easily to achieve the desired result on any part geometry. The latest software developments not only allow gray-scale manipulation, but also integration and marking of bar codes of any type. Bar codes and human-readable text can be substituted for each other by simply selecting the appropriate font style. Date codes and serialization routines are necessary for some products and many times are integrated into a marking system's software package. Marking information can be entered manually, automatically or semiautomatically.

For example, an operator can scan a bar code from an internal traveler document. The decoded information is entered into the proper data field, thus eliminating the chance of human error.

Once the data and part(s) are loaded, an operator initiates the start sequence. Depending on the system, the start



Trotec Laser's CO_2 laser marking machine.

sequence can also be automated. The beam of light reacting with the material is a thermal process. Because only light is making contact with the part, clamping it is not required. Also, marking results are not dependent on direct contact, such as with a stamp or a chemical etch, or how sharp the marking source is, such as with any CNC-manipulated device, dot peen or mechanical engraver. In fact, the lack of physical contact eliminates the need to be concerned about tooling misalignments or to replace or sharpen consumable items that are crucial for day-to-day mark quality.

The only precautionary measure to follow is to prevent direct eye contact with the laser beam. This is accomplished with the use of safety goggles or safety glass built into the laser marking machine's enclosure and used as a viewing window.

Maintenance

Today's lasers require little attention and can almost be considered a maintenance-free tool. State-of-the-art lasers require standard 110v, single-phase power. These lasers consume little power and are efficient enough to require only air cooling. Older lasers were less efficient and required external water cooling to keep the energy source at a safe operating temperature. In most cases, it is now more economical to operate a

Telesis Technologies

Telesis Technologies' Zenith Model 10F 10w fiber-pulsed laser.

laser than a standard hair dryer.

With lasers, an energy device is needed to ignite a gas, as with a CO_2 laser, a crystal, as with a YAG laser, or a fiber, as with a fiber laser, in order to excite the laser beam. Depending on the laser, the energy device can be a diode, lamp, glass tube or extruded aluminum tube. Replacing this source of energy is typically the only maintenance required. Technologies have improved such that the energy source can maintain its charge for 20,000 hours or longer.

Telesis Technologies

Telesis Technologies' Eclipse YAG laser can mark a range of materials and surfaces.

Laser Characteristics

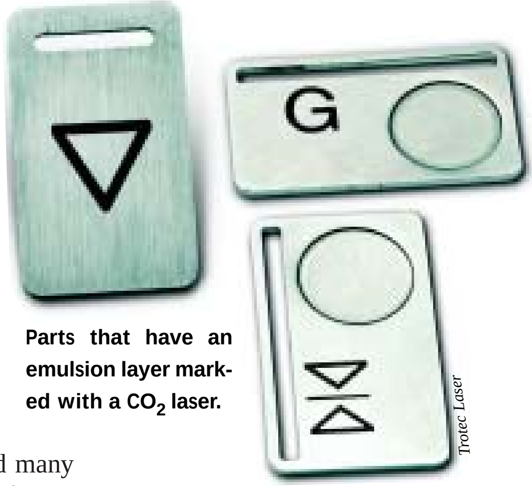
A general explanation describing the unique characteristics of each laser type is necessary to help choose the best laser for the job. YAG and fiber wavelengths are almost identical and produce similar marking results. The common denominator is a thermal reaction influencing the depth, color contrast or coating ablation. Each unique wavelength and respective spot diameter corresponds to different effects, depending on the material.

YAG and fiber laser spot diameters, as a function of wavelength and optics, are much smaller than CO_2 laser spot diameters. The smallest spots achievable with the CO_2 laser at its 10,600nm wavelength approach 0.004". The smallest spots achievable with the YAG laser at its fundamental 1,064nm wavelength approach 0.001". (The fiber laser's wavelength is 1,060nm).

Frequency-doubled YAG lasers (green laser at 532nm) and frequency-tripled YAG lasers (UV laser at 355nm) are usually lower power lasers, but the trade-off is smaller spots and a smaller heat-affected zone. Typical spot diameters achievable with the green laser approach 0.0006", and UV laser spot diameters approach 0.0003". Even smaller spots are achievable, depending on variables such as material and laser optics. Absorption characteristics with the green or UV laser may improve with certain materials, thereby increasing the range of materials that can be marked. In the case of the UV laser, the material response is so fast that the reaction takes place at a photochemical level rather than a thermal level.

Best Uses

Generally, CO_2 lasers are best for marking nonmetallic surfaces, including plastics—especially acrylics—rubber, ceramics, fabrics, glass and paper products. Other CO_2 laser applications include wood, stone such as marble or granite, ablating coatings such as anodized aluminum, and even food products. A few popular products include murals, awards, baseball bats, circuit boards, signs, rubber stamps and nameplates. Although the CO_2 laser may not efficiently mark metals directly, permanent marks can be achieved using an emulsion layer that is applied before marking. This emulsion bonds to the surface of the metal or other material and leaves a high contrasting, raised surface of typically 0.001".



Parts that have an emulsion layer marked with a CO_2 laser.

Trotec Laser

YAG and fiber lasers are best for directly marking metals and many plastics and removing a variety of coatings. As with the CO_2 lasers, many industries use YAG lasers. Commodity items such as razor blades and kitchen flatware are marked with a YAG laser. Other parts common to YAG marking include medical and dental equipment, aerospace parts and automotive parts.

Back-lit panels such as car stereo buttons, aircraft panels and cell phone keypads are also commonly marked by a YAG laser. A black paint is ablated, exposing an underlying white paint. When lit from the back, imperfections such as pin holes, lack of material removal or a less-than-perfect edge are exaggerated.

Ablation and other effects with YAG and fiber lasers are made possible with a Q-switch, or quality switch. This device allows marks to vary from a surface mark to a penetrating engraved mark. Using bare steel as an example, the laser at high Q-switch frequencies or continuous wave directly reacts with the carbon in the material and causes a black, or annealed, surface mark. An emulsion layer, as with CO_2, is not required. At a low Q-switch frequency, the laser penetrates the surface and removes as much as 0.003" of material in a single pass. Deeper penetrations are possible with multiple passes. Carbide cutting tools are also a common marking application, but even at high Q-switch frequencies, marking carbide tends to leave a frosted or white result. In contrast, the color of marks on titanium can be controlled by varying the laser's power and Q-switch settings.

Speedy Delivery

Marking speeds vary, depending on the type of beam delivery, laser power and material. The two most popular beam-delivery systems among YAG, fiber and CO_2 lasers are galvanometer and flying optic. The galvanometer is more appropriate for high-volume production as it offers much faster speeds, while the flying optic offers advantages in initial cost and typically processes larger areas without part movement.

Most YAG and fiber lasers use galvanometer delivery. Two small, motor-driven mirrors quickly reflect the laser beam in the X- and Y-axis positions in a predetermined marking field ranging from a 1" circle to a 16" circle. The material to be marked typically determines the appropriate marking field.

For instance, metals are typically marked through a lens with a corresponding 6" marking field diameter. Metals are reflective, but the 6" marking field lens creates beam energy density appropriate to overcome that surface reflectivity. Parts typically do not move, and if the laser power is sufficient to meet maximum marking speeds, specifications can be as fast as 500 characters per second with clear alphanumeric characters.

Material also has a bearing on marking speed. Because laser marking is a thermal process and plastics generally have low melting points, plastics can be marked quicker than other materials. For instance, a galvanometer-steered YAG or fiber laser leaves a black mark on clear polycarbonate at speeds between 20 in./sec. and 30 in./sec. Another plastic friendly to the YAG and fiber wavelengths is ABS (acrylonitrile butadiene styrene), which is widely used in the automotive industry. Other specially formulated, pigmented plastics make it possible to achieve marks of various colors.

Still other applications, such as marking anodized aluminum, also yield fast marking times. The anodized plating is ablated, thus creating a high-contrast mark by exposing the metal underneath. Marking speeds with the galvanometer often exceed 10 in./sec. In the case of bare steel, black surface marks require heat to bring carbon to the surface. This

Trotec Laser

The CO_2 laser beam delivered by the flying-optic delivery method.

need for more heat slows the laser's marking speed from 1 in./sec. to 3 in./sec, although many times, slower speeds can be compensated for with more power.

The CO_2 laser beam can also be delivered by the galvanometer, but CO_2 flying-optic delivery has become a niche in many industries. Lower initial investments have captured the attention of companies that have not considered laser technology. The CO_2 energy tube is remotely mounted and, with the use of mirrors, the laser beam travels across an X-axis carriage arm and then is directed through a lens where the beam is focused onto the material. The carriage arm is coordinated with a Y-axis travel mechanism as the X-axis moves in a raster (back and forth) motion of up to 140 in./sec. This is similar to the motion of a dot-matrix printer. Marking fields are measurable in large rectangles, such as 29"×17" or larger.

Considering all the variables, a laser's flexibility for marking or engraving different materials provides an avenue for creating indelible marks or aesthetically pleasing decorations on just about any part. Mark permanency satisfies regulations demanding cradle-to-grave legibility. Overall cost savings vs. competitive marking methods can be validated by comparing many factors, including labor, consumables, maintenance, product yield, safety precautions, setup and marking time. Users may discover new marketing advantages and other creative ideas to add value to a product or discover new products that may be marked that were never considered.

About the Author

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