rofin
LASER MARKING

Laser Marking of Edge-Lit – Back-Lit Panels

Complex graphical elements and MIL Standard fonts necessary for the aircraft industry realized through the use of Rofin-Baasel's advanced software features

The use of Nd:YAG Laser Marking Systems is widely gaining acceptance in the field of Edge lit - Back lit panels. Aerospace companies are beginning to realize the advantages laser marking offers over conventional engraving or photo-etch methods.

Flexibility, reprogramability, and speed are only a few of the key benefits laser marking offers. Our intent here is to "bring to light" this emerging technology, where it stands today, and what the future holds in this rapidly expanding field.

Panel Requirements

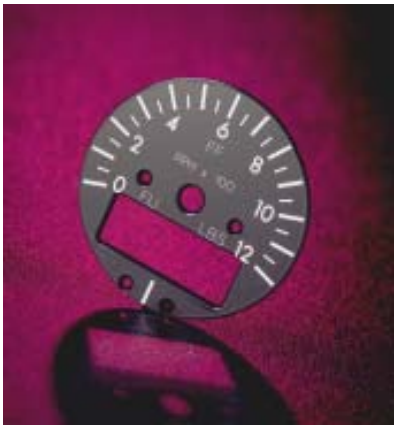
Aerospace panels are most typically made of transparent plastic in accordance with MIL-P-5425, finish A. The plastic panels are then painted, first with an undercoat of white paint, and then with a top coat of black, grey, or brown paint. The color of the underlying white paint must conform to FED-STD-595. This is accomplished by applying sufficient paint thickness to balance the color of the panel. This technique is often referred to as "Front toning".

Aerospace panels like this can now be processed much faster and at a fraction of the cost by using laser marking

The color of the topcoat must also conform to FED-STD-595. In this case, paint thickness must be sufficient enough to block all of the underlying white paint, but still be thin enough for the laser to quickly and cleanly remove this layer. Lacquer-based paints have been found to be excellent candidates for the laser marking process.

Extensive testing has concluded that the harder the paint, the cleaner the resulting mark. Paints which emulate glass-like finishes have produced the best results in terms of color and cleanliness.

Excessive top coat thickness creates a number of problems for the laser marking process; higher power levels and/or slower marking speeds must be employed. Because laser marking is a thermal-chemical process, excessive heat buildup at the point of contact can cause detrimental effects to the underlying white base coat. Yellowing, contamination, and material removal are the results of improperly balanced material and laser parameters.



Crisp, clean and well-defined legends are the result of an optimized paint-laser process

Nd:YAG Laser Marking Fundamentals

The Nd:YAG Laser

The Nd:YAG (Neodymium: Yttrium-Aluminum-Garnet) laser is the laser of choice

for Edge lit - Back lit panel applications. Several factors have influenced this decision to employ the YAG laser, as it is commonly referred.

At an operating wavelength of 1064 nanometers (near infrared) the laser beam is absorbed very efficiently by the dark lacquer-based paints. This, coupled with the YAG laser's ability to deliver a stable, high intensity source of light, has proven it to be the best choice technology has to offer today.

Some of the features which highlight Nd:YAG lasers are:

- **Laser type: CW, Nd:YAG**
- **Wavelength: 1064 nm**
- **Output power: 65 Wattscontinuous**
- **Operating mode: Multimode**
- **Modulation: 1-50 kHz, CW**

Marking System Design

Once the laser beam exits the laser, it then must be manipulated by a beam delivery system. In the case of Edge lit - Back lit panels, a galvanometer deflection system is used.

The galvanometer deflection system consists of two beam steering mirrors attached to galvanometer motors which manipulate the beam in an x-y fashion. The beam then passes through a flat field focusing lens which focuses the beam directly onto the workpiece. Flat field lenses are defined by their focal length, which in turn determines the mark field size, working clearance, and spot size.

The key element in flat field lenses is their ability to maintain consistent focus over a flat plane. This is accomplished by using multiple lens elements which eliminate the pendulum effect caused by scanning a beam across the lens surface. Mark field calibration and optical distortion correction are maintained using a Digital Signal Processor (DSP).

Nd:YAG laser marking systems in use today for Edge lit - Back lit applications are reliable tools using highly refined computer control. To develop a successful laser marking process, precise programmable control of process parameters under computer control include; laser power, laser pulse rate, and marking speed. Determining the best combination of these parameters will result in a reliable, robust process window.

Other parameters which must be considered but which are controlled manually include; lens size, and beam expansion ratio.

Operating Software

Edge lit - Back lit panel marking applications can place great demands on the operating software. Complex graphical elements and specialized fonts must be precisely imaged and located on all types of panel geometries. As is often the case, large panels which extend beyond the mark field limits create additional challenges for a panel manufacturer.

Today's marking systems feature Windows® based graphical user interface (GUI) environments which control all the various aspects of the marking process. This includes generating the marking data, laser process parameters, interaction with parts handling controllers, fume and dust collection, and communication with host computers. Because many of today's panel manufacturers use CAD based systems to create and lay out graphical elements and fonts, it has become a necessity of the laser software to allow for this data to be imported into the system.

The CAD Connection

AUTOCAD - CADMark - Laser Marker

Panel manufacturers today create and lay out graphical elements and fonts using CAD based packages such as AUTOCAD.

In response to this, Rofin-Baasel has developed a program generator which allows the panel manufacturer to seamlessly create laser programs from within AUTOCAD. This program generator, known as "CADMark", allows the CAD user to link his graphics and fonts with laser parameters, paint types and colors, lens sizes, and motion table positions.

Once the environment has been initialized, the CAD user can then determine if his layout can be marked within one mark field, or if his drawing will need to be "tiled". Tiling is simply breaking the drawing into squares and then piecing these squares (tiles) back together using table motion to move the panel fromone tile to the next. To do so, the CAD user selects the tiling command, and based on the selected lens (which determines the tile size) a square will appear on the drawing which the CAD

After two coats of paint and laser marking, a transparent plastic shape has become a finished car radio front panel in Back Lit Panel design

user then places over the first area to be marked. The square area represents the area which the laser can guaranty accuracy between tiles.

Once the CAD user has selected the desired tile location, all entities which cross the tile boundary are broken and copied along with all other entities contained within the square to the appropriate tile layer. The CAD user continues to tile the drawing until all of the entities have been selected.

To Boldly Mark with Pinpoint Precision

The typical spot size of the laser beam as delivered to the workpiece is roughly .005" (.125mm). Because of the small spot size and resulting linewidth, bold text and graphics require multiple overlapping strokes to achieve desired boldness.

Within the CADMark program polylines drawn with width are transformed into outline form. Each polyline is then filled using the offset command. The number of fill lines depends on the polyline width, the beam width, and the minimum overlap percent.

Once the drawing has been tiled and filled properly, the drawing is then output from AUTO-CAD, and the CADMark program generator creates the laser program including table motion commands, laser parameter, and font and logo files.

The program can then be down loaded from the CAD station using SECS-II protocol via an RS232 interface or stored on a diskette and loaded manually.

The Future of Laser Marking

LaserCAD

With so much of the layout work being performed using CAD-based packages today, Rofin-Baasel has designed their own CAD-based operating system as a means of simplifying the task of program layout and management, known as “LaserCAD” (Figure 1).

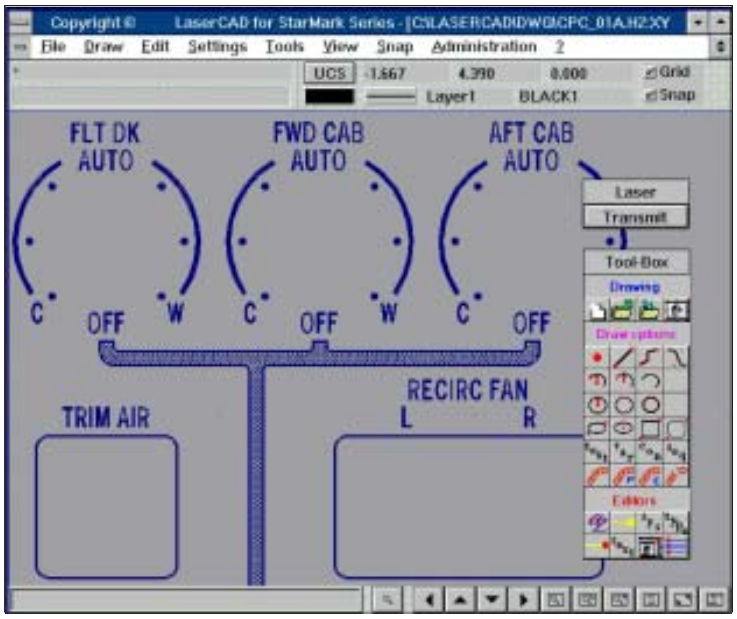


Fig. 1. With "LaserCAD" panel layout, parameter linking and part/beam motion are managed within a single operating system

LaserCAD incorporates commands similar in many respects to those adopted by well-known CAD programs like AUTOCAD.

Using an integrated CAD program allows the laser programmer to perform all the necessary layout, editing and outputting of marking program within one operating environment. Running in WINDOWS, program generation and modification has become extraordinarily simple and fast due to its graphics-oriented operation and menu controlled user interface.

With LaserCAD, the programmer now has access to a full featured text editor, integrated CAD program, processing of standard CAD formats (i.e. *.DXF), object-oriented laser parameter mapping, and on-line/off-line programming. Filling of complex graphics and text is also much simpler by virtue of “intelligent” computer controlled automatic filling routines.

Laser Parameters for Panel Marking

As a result of exhaustive testing, Rofin-Baasel and panel manufacturers have succeeded in developing parameters for the processing of high coverage paint systems. The laser marked images are obtained by using a two-pass operation.

The first pass removes the bulk of the top coat of paint without causing damage to the base white layer. Removal is accomplished at moderately high speeds with pulsed mode being used. With high peak pulse power and low average power, paint is removed with minimal heat effect.

The second pass serves as a cleaning function which leaves the image clean, well-defined and damage free. The cleaning pass is typically done at high pulse rates, thus reducing the peak pulse power, but increasing the average power. The use of high pulse rates allows for much faster marking speeds, which in turn keeps the white base coat free from damage and discoloration.

After establishing the two pass procedure, the process has proven itself to be reliable with a broad window of operation. This process has proven itself to be compatible with long-term repeatability requirements, in that minor changes to the laser process or the paint

system did not adversely affect the marking results.

System Review

The system consists of a Nd:YAG multimode laser with either one or two galvanometer scanner deflector units using flat field lenses. The laser system corresponds to CDRH laser Class One (i.e. no hazardous emissions can escape from the enclosure). If a door or lid of the housing is opened, the laser beam is shut off immediately.

Optional Features

A number of optional features can be incorporated into a laser marking system. Some are designed to increase throughput while others are used to enhance accuracy.

A single laser source can be coupled to either a single or dual galvanometer deflection head. By using a dual deflection head and a beam splitting unit, two panels can be marked simultaneously, thus effectively doubling the throughput of the system at a fraction of the cost.

Replacing the beam splitter with a beam switching unit enables the system to provide double the available mark area. This feature is helpful when part motion can't be employed.

Rofin-Baasel's UW-180 laser marking system with tiling options used in the production of aerospace panels

Another useful option is the programmable aperture, which allows quick change from one beam width to another. A good example of where a programmable aperture can help is where graphics or text must have sharp, well-defined corners and also contain a bold stroke. In this case a small diameter aperture would be used to draw the outline of the character and, with a quick switch to a larger aperture, the filling of the image can be produced using less overlapping of laser tracks.

Advantages of Laser Marking

Applications involving the use of Nd:YAG lasers to mark Edge lit - Back lit panels have increased significantly in the last several years. This is largely due to several characteristics of laser marking and the advantages they offer when compared to photo etch or conventional engraving methods.

Setup time can be substantially reduced, laser mark layouts can be easily created in CAD programs such as LaserCAD for efficient production of new designs.

- Laser marking contains a high degree of flexibility, all parameters of laser marking can be programmed via computer.
- Legibility of small characters: Lasers can produce characters 0.020" high that are sharp and well-defined.
- Repeatable placement of marks.
- Laser marking is a non-contact process, therefore no tool wear is encountered.
- Clean, environmentally friendly process.
- Laser marking can easily access small indented areas that conventional techniques cannot touch.
- Easy integration into automated production lines.
- Low operating cost.

By using laser marking technology, today's panel manufacturers can realize substantial cost savings when compared to photo etch or engraving technologies.

With the advances in painting systems yielding higher quality coatings, laser marking has become an attractive alternative to conventional techniques.

In this world of just-in-time manufacturing, laser marking gives the panel manufacturer the advantage they need to remain competitive in this demanding field.

For information on this or other laser marking, welding, or cutting applications, contact the Laser Professionals at Rofin-Baasel Inc.

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