Measuring Beam Characteristics for Successful Laser Marking

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Having worked in laser marking and engraving for several years, I can say that there is a certain mindset when it comes to laser quality that, in some cases, could be a dangerous one, especially in industrial applications. The mindset is, “If the laser is making a mark, then why check the performance of the laser?” Let’s discuss this as it relates to several different laser applications, including why this mindset could be causing you to lose time and money.

Industrial laser markers are used in just about every market segment today... too many different applications to be discussed in one article. For purposes of this discussion, the term “laser marking” will envelop several processes, including etching, engraving, ablating, and annealing (each having its own variety of definitions). Some marks are a thermal process, some are mechanical, and some are chemical. Laser marking can be performed on a wide variety of materials, such as metals, plastics, painted surfaces, and organic materials. There really doesn’t seem to be an end to the ways lasers can be used to put a permanent mark on materials.

The development of lasers for marking isn’t that different from other similar laser technologies. High-powered Nd:YAG lasers (usually in the 100s of Watts) have been the bedrock of industrial part marking for decades; they are still being used today where raw horsepower is needed for the application. However, the fiber laser is proving to be a key player in laser part marking with its high beam quality and relatively low total cost of ownership.

Figure 1. Example of Typical Laser Marking System
Another technology that is also providing high quality and stable beams with great flexibility for the laser user is a hybrid of these two technologies. In this case, the laser source is a diode-pumped crystal with a fiber-delivery system, which homogenizes the beam being delivered to the process.

Working with laser marking technologies is just as exciting as the development of laser cutting, welding, additive manufacturing, or any other laser technologies and applications.

However, all lasers are made of matter and matter degrades and eventually fails. These physical changes to the laser system will result in changes in beam quality and beam output power or energy and even the shape and/or size of the beam. And because of this law of nature, the mindset toward the monitoring of the performance of these laser systems should be no different than in any other laser application. The fact is, if the laser is not monitored for performance, there will come a time when the laser user has to deal with expensive technician visits, part replacement, and production down time.

Regardless of the type of laser or the laser’s function, at what times during the life cycle of the laser system should these laser performance measurements take place to ensure a successful long-term laser application?

Deep Engraving
Let’s examine the laser application known as deep engraving. Deep engraving is needed for certain part marks to ensure that the mark is permanent and visible for long periods of time. In some cases, the specifications of the depths of the marks are actually regulated by agencies overseeing the manufacturing of the products.

The part marks are sometimes covered with a coating or anodizing, which is why the depths are under such scrutiny. As with any industrial process, time is money. So the quicker the part is marked at the desired depth depends directly on the performance of the laser. Laser output power or energy per pulse should be constantly monitored during the development of the laser application AND after the laser is put into production, so that the laser process has a consistently high throughput. In addition, the measurement of the consistency of the laser spot size is crucial, since the area within the laser spot will determine the power or energy
density at the workpiece. If either the laser power/energy or the spot size changes over time, so will the laser process.

**Plastics Marking**

Another application where the laser is used for rapid part marking is in plastics marking. When the chemistry of the plastic is right, the laser produces a high-contrast permanent mark, sometimes in fractions of a second (depending on the content of the mark). I can say from personal experience that much time is put into the application of the laser in these processes to ensure that the process is optimized on the front end, as the laser is often put onto a production line where high throughput is a must. With any material processing where the laser is involved, the laser’s **power density** (laser power with respect to the beam size) needs to be optimized to obtain the desired effect. Plastic marking is no different.

There are several tricks that the laser applications engineer has in his arsenal when it comes to plastic marking. One of them is to increase the **spot size** (either through optical configuration or applying the laser slightly out of focus) to achieve a higher-contrast mark and quicker fill speeds. However, how is the process transferred from the laser where the application was developed to the laser that is put into production? The best way to achieve this is through laser measurements. Only by measuring the laser’s **power or energy**, and the measurement and viewing of the laser’s **spot size** can the laser application best ensure that the result on the production laser is the same as the applications lab’s laser. And, if things go wrong in production, these measurements will prove to be invaluable for returning the production laser to the benchmark of the original laser’s performance.

**Avoid Vulnerability**

It is true that laser marking applications have their own unique set of issues and approaches. But what is not unique is that it is still an application of a laser and the same laser performance and maintenance issues apply to these lasers performing part marking. The bottom line is that, if you are not measuring your laser’s performance characteristics for its optimized settings and for consistent performance, you leave one of your most costly investments vulnerable.

Whether you are on the front end of application development or are an end user responsible for maintaining high production throughput, if you are not monitoring
your laser’s performance, you are running the risk of spending unneeded time and money when the laser needs to be brought back up to par. “An ounce of prevention is worth a pound of cure” is certainly true when it comes to any laser application, including laser marking.