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Autofocus for Laser Marking, Welding, Drilling and Cutting Systems Using Optimet's Non-Contact Distance Sensors

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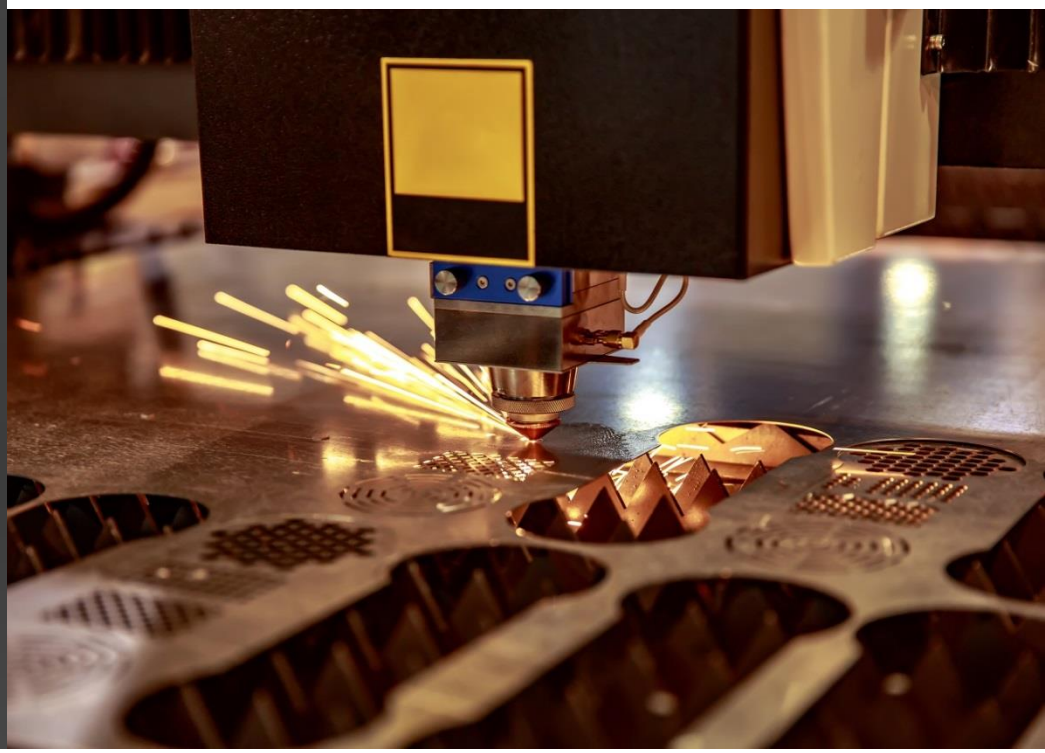
Introduction

Conventional laser marking, welding, drilling and cutting systems often struggle with focusing the laser precisely on the object's surface. We propose a new laser measurement method that integrates Optimet sensors into laser systems, providing the vast benefits of autofocus capabilities. Integration with Optimet sensors upgrades laser system performances such as speed and yield, and facilitates the user's control of the laser system parameters.

Figure 1: Conventional Laser Marking System



Needs

The need to control the laser system's laser focal point is becoming crucial as the demand for faster and more accurate manufacturing processes increases. The Z position of shaped objects and/or the lens focusing point must be controlled in order to surmount both the complexity setting and the user's expertise of the laser system.

Old Measurement Principle

Two standard methods are currently used in the industry for measuring distances.

The first and more conventional way is to set up the laser's 3D motion parameters using a CAD (computer-aided design or drawing) of the sample. This method requires the user to be an expert at reading and understanding CAD files and then be able to translate the design to the motion of the laser system in three axes.

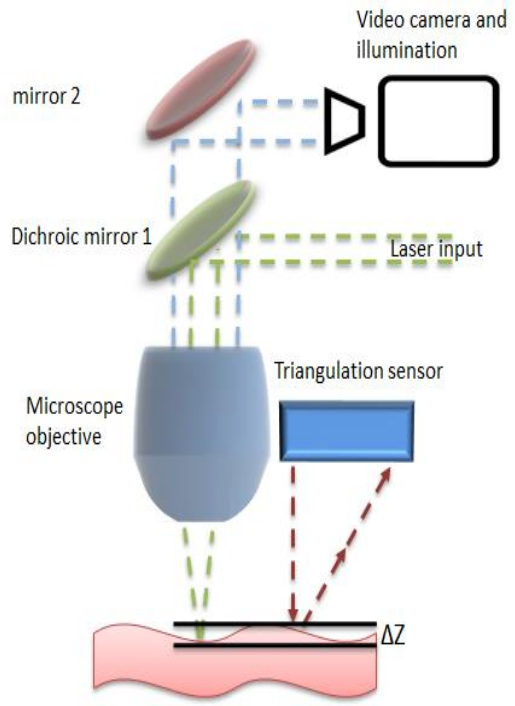


Figure 2: Distance sensor in off axis principle

The second method is often used when a CAD model or drawing is not available, for example in a welding repair process. The user attaches an off axis distance sensor, such as a triangulation displacement sensor or a camera, to the object (see Figure 2). This sensor measures the distance to the object before the cutting laser is emitted, and then calculates the Z difference the laser system needs to be moved up or down to reach the required focus. Three axes (X, Y, Z) adjustment of the laser system is required to coordinate the spatial shift difference of the sensor or the object. This method has its limitations depending on the shape and angle of the object's surface. For example, it is accurate only when the scanning sensor moves ahead of the laser system. In addition, a hot environment would require the sensor to be far away from the surface, necessitating a long clearance distance that produces lower accuracy in measurements. As the distance between the sensor and the target increases, accuracy decreases.

New Measurement Principle Using Optimet Sensors

Optimet sensors offer a unique solution for autofocusing laser systems. Integrating Optimet's non-contact distance measurement sensors into laser systems improves the autofocus functionality, facilitates the laser system setup, and simplifies measuring when there is no CAD available. Optimet sensors measure distance using a unique co-linear Conoscopic Holography technology and can be applied in the laser system's optical path. In addition, since the sensor's illumination design is collimated, the lens can be far from the sensor because measurement is performed through the objective lens of the laser system itself! Some of our customers have successfully integrated the sensor as far as two meters from the laser's objective lens.

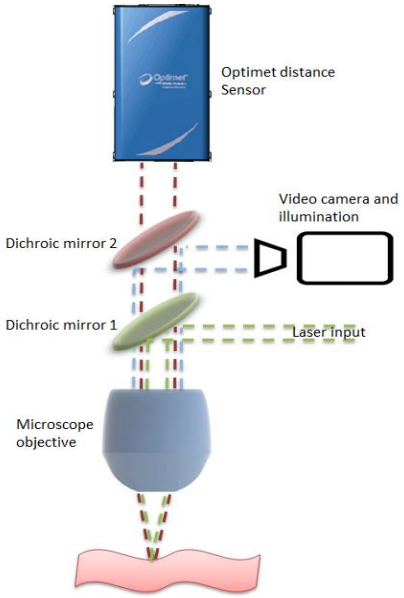


Figure 3: Optimet sensor integrated into a laser system for autofocus tracking

Limitations in Conventional Systems

An object under process can be flat or curved, and it may need to be marked, cut or welded. Therefore, a laser marking, welding, drilling and cutting system requires movement in all three axes of the system. This requires a trained and experienced operator who must also know how to read the CAD of the object and program it into the laser system.

Figure 4: Curved object marked by a laser marking system

Some of the main problems with conventional systems are:

- Setting the object at the right operating distance (correct focal length).
- If the object is not flat or if more than a simple line cut is required, a drawing is needed and the operator must know how to read the drawing correctly.
- Three axes operational setup is needed which can make the settings difficult to achieve. Again, an experienced operator is needed.
- If the laser is out of focus there is no real time feedback indicating that correction is needed.
- Speed is limited due to the lack of focus during the process.
- Distance sensors and cameras are mounted off-axis from the laser's focal point and require software alignment and pre-calibration.

- If the sample has sharp angles or deep holes, shadowing might occur and there would be no feedback from the distance sensor to correct the laser system.
- When depth of drilling or marking is critical, feedback of that point is needed from the distance sensor in real time.

All of the above issues make the operation of conventional systems complicated, inefficient, inaccurate, and require an expert operator.

Measurement Challenge #1: Scanning at the Same Principle Point

To measure the distance to an object at the same principle point (position where the laser system hits the surface) as the laser marking, welding, drilling or cutting system, the physical parameters of the distance need to be obtained. This can be done only with collinear technology in which the outgoing laser beam shares the same optical axis as the signal reflected back from the surface into the sensor.

Optimet's patented Conoscopic Holography technology has a unique collinearity property that enables measurement at the same principle point and can also measure inside narrow holes or steep surfaces up to ±85°.

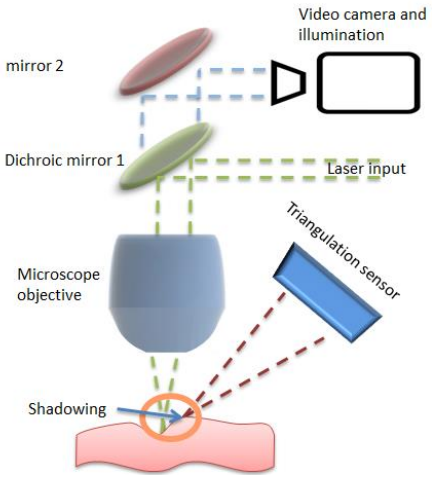


Figure 5: Shadowing effect when trying to use a triangulation sensor or a camera on a curved object

Measurement Challenge #2: Scanning with a Remote Lens

Working with a remote lens - where the lens is not mechanically attached to the sensor - is a unique challenge in the laser system industry. Every laser system uses its own lens with different parameters and a specific optical design. The distance sensor must be able to collect distance information without being affected by the objective lens and/or optical difference, and it must be able to work with the laser system's objective lens itself, often an F-theta lens. This can only be achieved if the laser coming out of the distance sensor and the signal reflected back from the surface are collimated so that all rays are parallel and do not focus at any distance. This ensures that the measurements are not affected by use of different types of objective lenses. Optimet's technology offers this exact property, enabling the development of sensors that can work with remote lenses placed up to two meters from the sensor.

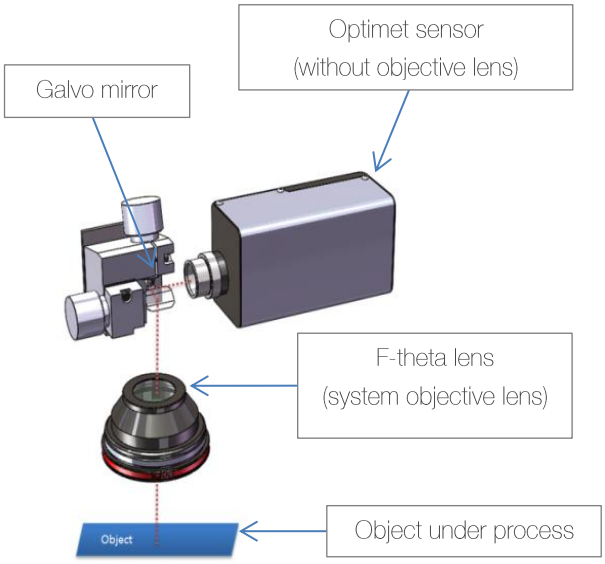


Figure 6: Optimet sensor integration into a cutting system using one shared optical path

Optimet sensors can be calibrated using the same type of objective lens as the marking, welding, drilling or cutting laser system and at the same distance from the lens to the sensor, while maintaining the same calibration parameters as if it were placed in the laser system itself.

Only Optimet sensors and technology can resolve these two unique challenges!

The Benefits of Using Optimet Sensors

- Continuous distance data of the object's top surface at a rate of 0.05 milliseconds allows the system to always be in focus regardless of the surface shape.
- The sensor's speed is several times faster than the laser's motion system, resulting in a high measurement rate that enables laser systems to run faster than in any other system configuration.
- Using the adjustable focus in real time provides accurate color shade in laser marking systems.
- The auto-exposure function of Optimet sensors automatically adjusts the sensor's exposure and enables accurate measurement even when moving from black surfaces with low reflectivity (0.3%) to white surfaces with high reflectivity (99%).

Summary

The ability to autofocus laser systems is becoming increasingly imperative. Optimet sensors make it easy to receive feedback from the same principle point. Integrating Optimet sensors into laser marking, welding, drilling and cutting systems is a proven solution that can make your system work faster and more precisely with increased yield, without depending on expert operators.

For more information please visit our website http://www.optimet.com