Increase Your Laser System's Lifetime

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Introduction

When using lasers in an industrial setting, there are many sources of unbudgeted costs. Among these costs are costs of replacing lenses and reflectors damaged in use, the costs of remachining parts which were incorrectly machined due to alignment or laser quality problems, and down time for unexpected repairs.

Although none of the sources of unbudgeted costs can be eliminated, many can be ameliorated by a properly implemented routine maintenance program. Such a program prevents many problems by anticipating and eliminating the causes, and reduces the damage of others by detecting blemishes before they turn into disasters. Those companies which have implemented effective routine maintenance programs have mean times between failure of their laser machining systems several times longer, and mean times to repair these systems several times shorter, than companies that have no such program.

This paper presents an example of a routine maintenance program. This program does take some time to implement, probably about five to six hours per month, but this time is likely to be less than the down time prevented by its implementation. When one also recalls the cost reduction due to avoidance of unexpected replacements and remachining, it becomes obvious that implementing a good maintenance program pays for itself in increased efficiency and reduced down time.

Daily Maintenance

The following routine maintenance tasks are recommended to be performed on a daily basis:

Check Laser Power

The most basic test of the laser itself is its output power, determined by reading the power meter on the control panel. The laser power should not change if the control settings do not change. This measurement must be recorded and graphed daily.

Decreasing power may indicate laser misalignment or damage. If the power is varying slightly (<5%) over time, both increasing and decreasing, there is no cause for worry; this is within experimental error. If, however, the laser power changes more than 5% in 24 hours, something may be wrong with it (see Fig. 1 for a graph demonstrating this sudden reduction in laser power). Also, if the graph of laser power *vs.* time indicates a decreasing trend, the laser is almost certainly misaligned or has damaged optics. Usually, if the graph shows a straight line decrease in the power (see Fig. 2), the decrease is caused by misalignment; if the graph shows the laser power dropping in a curve with increasing rapidity (see Fig. 3), this often means that the laser output coupler is damaged.

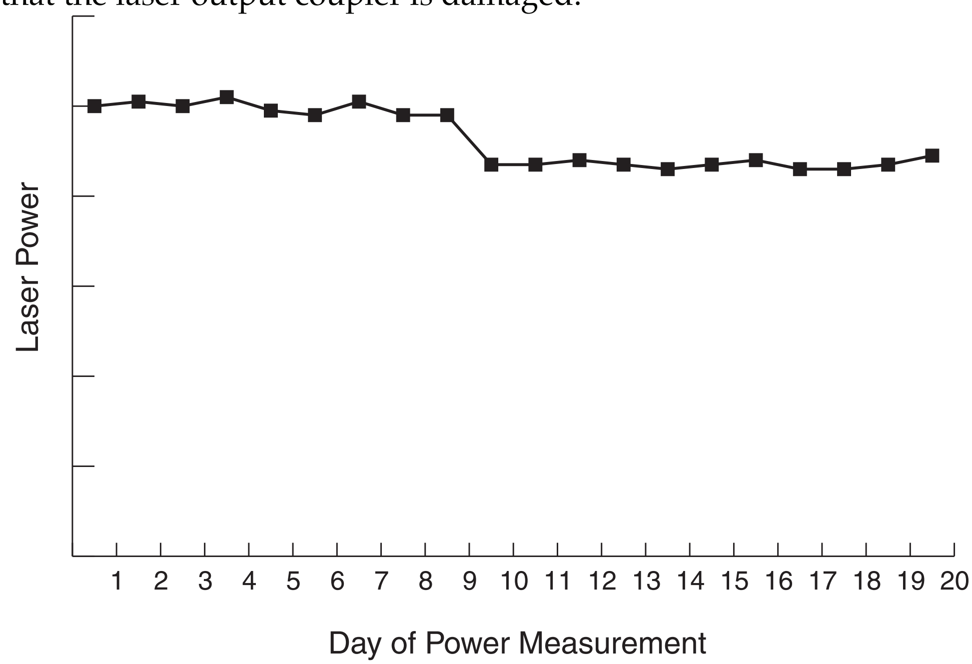

Figure 1. Graph showing a sudden drop in laser power, indicating a probable problem in the laser cavity.

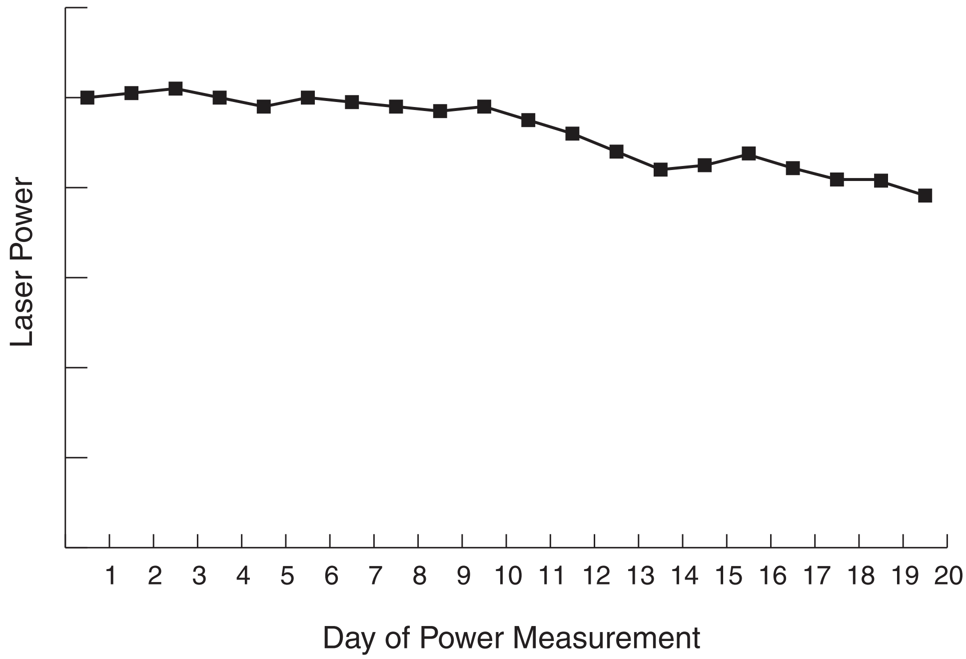

Figure 2. Graph showing a gradual, linear drop in laser power, suggesting a misalignment of the laser cavity.

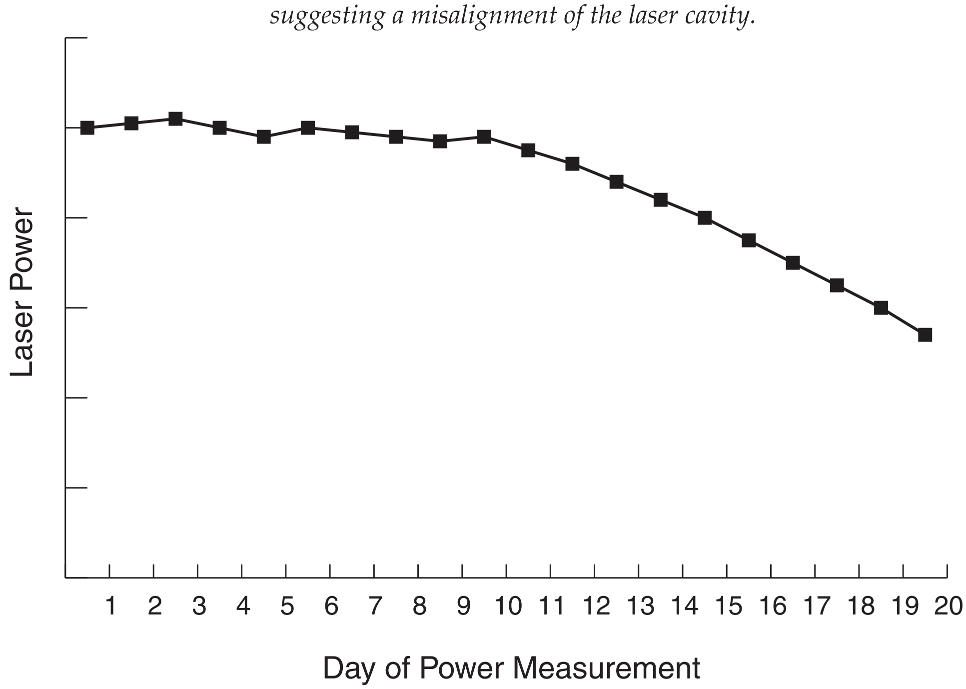

Figure 3. Graph showing an increasing drop in laser power, potentially caused by damage to the laser's output coupler.

Check Required Power for Test Cut

If the laser passes the power test, the power required to cut a piece of test material should be recorded. As long as there has been no change in the laser's condition there should be no change in the power required to cut the material.

If the required power to cut the test material increases, the laser beam is no longer reaching the intensity it did before. Since the laser power has not itself decreased, the beam quality must have decreased. This is often due to damage either to the output coupler or to the focusing lens. Again, power variations of 5% are not unusual; much larger variations are an indicator of damage.

Check Quality of Test Cut

After cutting the test material, the cut itself must be inspected. A decrease in the smoothness of the cut indicates a decrease in the beam quality, which may be caused by damage to the output coupler, damage to the focusing lens, beam-to-orifice misalignment or laser cavity misalignment.

Blow Dust from Upper Surface of Lens

Using clean, low-pressure gas (such as Dust-Off with a diffuser), blow the collected dust off the top surface of the lens. *Do not use shop air* as this usually has oil or other liquid contaminants as well as being at a pressure that may damage the lens.

Weekly Maintenance

It is recommended that the following maintenance be performed weekly:

Align Laser Cavity

Regardless of the laser beam's power and quality, the laser cavity must be aligned regularly. To align the cavity, adjust the angle of the output coupler. (Some lasers also require alignment of the back mirror—check your laser manual.) Continue adjusting until the maximum power has been reached. When the laser is at its best alignment, small adjustments will make virtually no difference in the output power. This alignment should be the best both for power and for beam quality.

Center Beam in Orifice

With the laser beam on, adjust the orifice position to allow the maximum laser power through it. If the orifice is misaligned the beam will clip on it, which reduces the laser power and degrades the beam quality. Since both beam quality and laser power contribute to the ability of the system to do its job, a misaligned orifice can cause severe machining problems.

Clean or Replace Orifice

Remove the orifice and clean it with reagent-grade propanol and/or acetone (use of reagent grade ensures that there are no contaminants). If possible, clean the orifice in an ultrasonic cleaner. If the orifice is dirty it will have the same effect as if it is misaligned.

The orifice is used to prevent backsplatter from reaching the focusing lens. In normal use, it will eventually be widened by erosion and the laser beam, and may become irregular due to material backsplatter. In either of these cases, the orifice must be replaced to allow it to protect the focusing lens.

Wipe Beam Path with Oiled Cloth

Clean the laser beam path with a lightly oiled cloth. Do not use this cloth on optics.

Refocus Focusing Lens

Adjust the z-axis (vertical) of the lens so that the laser is focused at its nominal position. This must be done every time the lens is cleaned or replaced.

Realign Focusing Lens

Adjust the tilt (θ and ϕ) of the lens to produce the smallest, roundest focal spot. This must be done every time the lens is refocused.

Change Air Filter on Water Chiller

Remove and replace the air filter on the refrigeration system of the water chiller. Dust and other pollutants can build up in this filter, reducing the chiller's efficiency and preventing it from keeping the water as cold as it must be.

Change Panel Air Conditioner Filter

Remove and replace the air filter on the cooling system of the control panel.

Monthly Maintenance

It is recommended that, each month, the following tasks be performed:

Align Table Origin to Beam Focus Point (*x*- and *y*-axes)

With the laser running, move the table until the laser beam is striking its (0, 0) location. Set the controls so that they also read (0, 0).

Clean or Replace Focusing Lens

Dismount the focusing lens. Inspect it carefully for damage or discoloration. If there is none evident, carefully clean the lens before remounting it (see cleaning instructions below). If the lens has only minor damage or discoloration, clean it and reinspect it; if the apparent damage or discoloration has been removed by cleaning, the lens may be remounted. If the appearance of the lens is not improved by cleaning, or if the damage or discoloration is not minor, replace the lens and mount the new one. Have the damaged lens evaluated for possible refurbishment.

The quality of the focusing lens is one of the most important factors in the quality of the laser beam used for machining. Any imperfections in the lens will reduce the ability of the machining system to do a good job.

Routine cleaning and inspection of the focusing lens can often spot problems before they become unmanageable. A properly cleaned lens is less likely to get damaged in ordinary use, and if there is damage to the lens, removing it before the damage becomes widespread increases the probability that the lens can be refurbished, at a lower cost than buying a replacement lens.

Lens Cleaning Instructions: First, gently blow the dust off the surface you are cleaning using a low pressure gas, such as a Dust-Off can with a diffuser. (We do not recommend using a squeeze bulb, as the chance of damage to the lens is too high.) Then take an optical-quality cotton ball or quilted cotton pad (optical-quality cotton is lint-free surgical-quality cotton). Dampen this cotton with reagent-grade propanol or acetone (these organic cleaners will not leave deposits which absorb the laser radiation). Gently wipe the lens surface with the dampened cotton, moving fast enough that the propanol or acetone is evaporating just behind the cotton. Continue, replacing each cotton ball or pad as it is used, until the lens surface is clean.

Be very careful handling the CO_2 laser focusing lenses. They are made of very soft materials with fragile coatings, and cannot withstand the types of cleaning used on glass or reflectors. Also, any scratches or even fingerprints can ruin a focusing lens. Be sure that the area used for cleaning the lens is clean, and only clean lenses while wearing finger cots or lens-handling gloves.

Check and Clean Assist Gas Filters

Remove and clean the filters in the input and output paths of the assist gas flow. Check the filters as described in the filter manuals. Care of the output filter is especially critical, as this collects some of the detritus produced by laser machining.

Add Biocide to Chiller Water

Open the chiller water tank and add the recommended amount of biocide. This prevents algae and other organic growth in the water lines. The organic growths not only smell bad but can damage the sensitive laser equipment, as well as forcing replacement of the water lines by growing inside them.

Add Biocide to Lens Coolant

Open the lens coolant tank and add the recommended amount of biocide.

Check/Replace Chiller Water Filter

Remove the chiller water filter. Back-flush it and check it for free forward flow. If the flow is restricted, or the filter is discolored, replace it with a new one. This helps prevent blockages in the water line and damage to sensitive laser components.

Check/Refill Chiller Water Level

Check the level of water in the chiller. If it is below normal operating levels, add distilled or deionized water to the tank until the level is just below the maximum for normal operation. This will help prevent overheating caused by low water levels.

Check/Replace Lens Coolant Filter

Remove the lens coolant filter. Back-flush it and check it for free forward flow. If the flow is restricted, or the filter is discolored, replace it with a new one.

Check/Refill Lens Coolant Level

Check the level of coolant in the lens coolant reservoir. If it is below normal operating levels, add coolant to the reservoir until the level is just below the maximum for normal operation.

Quarterly Maintenance

Every three months the following maintenance should be performed:

Align, Clean and Lubricate Beam Delivery System

First, clean the beam delivery system with water and an organic cleaner such as propanol or acetone. Then lubricate all joints. Wipe the beam path with an oiled cloth. Finally, realign the beam path so that the laser passes through the center of the path and does not strike the edges.

Semi-Annual Maintenance

The following maintenance task is recommended at six-month intervals:

Completely Rebuild Laser Cavity

Every six months, the laser cavity should be completely rebuilt. This includes dismounting, cleaning and inspecting the internal cavity optics, and replacing them if necessary; cleaning or replacing the gas flow tube; replacing the electrodes; and reassembling and realigning the optical path. *All* internal optics, gas flow surfaces, electrodes and electrical connections must be cleaned and inspected, and replaced if necessary.

Summary

In the industrial use of lasers, there will always be unexpected and unbudgeted costs. These costs can be minimized by proper use of a routine maintenance program, such as the one suggested in this paper. Implementing such a program can increase the efficiency and reliability of a laser machining system.