Euro Laser

It's a kind of magic

Special Manuscript from EuroLaser (1/09)
Journal of Industrial Laser Applications, March 2009–05–31
The way laser lenses keep in pace with the constantly increasing outputs of laser beams

It’s a kind of magic

CLEARMagic™

The constantly increasing outputs of laser-cutting systems pose a real challenge on the lenses, because in the case of high-output laser beams, a rather low absorption rate is required in order to maintain full and constant process control. Lens makers like Ophir Optronics took on the challenge and have developed lenses that are not only able to cope with the highest available laser outputs, but also have a higher lifespan in comparison with their predecessors, despite the higher outputs.

In recent years, lasers in laser-cutting systems exhibit an annual increase of 1-2% in output. Over time, the default maximum 4 kW was replaced by 5 kW, then 6 kW and 7 kW systems are currently available as well. This has implications not only on the laser source itself, but also on the containment system as a whole. The machine dynamics must provide higher cutting speeds in order to comply with the higher laser outputs, the cutting table must be comprised of thicker and thicker metal sheets to sustain the increasing loads, and albeit higher outputs, the lenses should be protected against overheating.

EZ Pack™ - New Kind of Packing

Until now, it was customary to develop the lenses within a specially made laser-paper, then inside a small plastic bag, and finally everything was transferred into a designated plastic box. The new packing by Ophir Optronics enables one now to refrain from the use of the laser papers as well as the additional plastic bags. The lenses are placed in a plastic skin that is designed in a way that prevents a direct contact between the lens surface and the packing. The plastic skin is then welded into an aluminum foil and placed inside the plastic packing, ensuring that the lenses arrive at the customers in a perfectly clean and undamaged condition. This new packing was introduced by Ophir Optronics during last year and proved itself to be excellent: now, once the user has received the lens he can unpack it and immediately install it for his needs. No additional cleaning is required.

Dr. Jürgen Kolbe, CEO of Ophir Optronics GmbH:
“My suggestion to every lens user would be to handle the lenses with care, integrate them properly, and regularly clean them – it is worth it.”

According to Dr. Jürgen Kolbe, such apprehensions are senseless in view of the massive progress achieved in the field of laser lenses. “In recent years extensive work done on laser lenses. For example, the quality of the standard coating has been considerably improved. Absorption rate values of 0.25 to 0.3 percent which were common 10 or 15 years ago were replaced by today’s standard values of 0.2 percent. The Black Magic™ lens which was introduced by us 10 years ago absorbs just 0.15% of the laser energy and our most recent lens, the Clear Magic™, absorbs no more than 0.13%.

Dr. Kolbe is convinced that when speaking about absorption rates, it is worthwhile to take two digits after the decimal point into account. “Heat is deposited into the lens in the process of laser-energy absorption. For concurrent typical CO_2-laser outputs of 5 kW working in conjunction with a standard 0.2% absorption lens that would make about 10 Watts. However, during the cutting process, one must bear in mind that the heating of the lens inflicts a shift of the focal point in an upward direction. In this way, problems affecting the quality of the process as well as its security are inevitable.

From Dr. Kolbe's experience, the problems affecting the quality are the most prominent when cutting at larger metal-sheet thicknesses: "When attempting to cut steel thickness of 10mm or more, the focal point must constantly reside at the same Z-axis position in the center of the sheet. The shifting of the focal point might result in a combination of feathering at the bottom side and unclean cutting edges.

Moreover, it will also decrease the maximal cutting speed reachable.
The pivotal element of reducing the absorbed laser energy is its coating, rather than the lens material. The reason for this is that no more than 0.05% of the absorption take place in the bulk, while most of the absorption take place at the coating and upper surface. It is due to a high-quality anti-reflex coating, which allows the seamless operation of the lens. The lens coating process at the manufacturer is a hot topic today, as one would expect. This is because the process naturally takes place in a high vacuum, and involves the setting and optimization of countless process parameters, which aim to obtain a perfect condensation of the lens on the surface.

The Ophir Optronics factory in Israel probably has a good handle on this process. This becomes evident by the fact that the Black and Clear Magic coatings exhibit not only low absorption rates, but also a rather high mechanical stability. This not only extends the lenses' lifespan, but as the surface is less sensitive to scratching, it also simplifies the cleaning and maintenance of the lenses.

The cleaning of the lens is optimally performed with a specially-made chemical-free cleaning paper that can also damage the lens when used in conjunction with cleaning liquids such as Ethanol, Propane, or acids. According to Dr. Kolbe, many users of laser cutters underestimate the importance of the cleaning of the lenses: "Some users go so far that they never clean their lenses. As a result, the lenses are being mishandled until they become useless, and then they are simply replaced by new ones."

When weighting the price of a regular lens, namely €200-300 against the estimated loss of income involved with the system downtime and costs of cleaning, it might seem that simply exploiting the lens until full degradation and then replacing it with a new one makes good economic sense. However, one important factor is usually disregarded in the above consideration: maltreatment causes an inevitable degradation of the security and the quality of the cutting process. Therefore, Dr. Kolbe strongly recommends a frequent and thorough cleaning of the lenses.

In order to be satisfied with prolonged focusing of the lens, it is extremely important that the installation of the tube and the tuning of the beam be as accurate as possible. This is because optimal cutting results are achieved with the radiation passing through the axis of the lens and the tube. Both conditions must be fulfilled by the user, since as before, they cannot be adjusted to up a reasonable level by any automatic procedure. In this way, the use of the lense is strongly dependant on the capabilities of the user, where handling mistakes and negligence may gravely affect its usability.

This can vary within quite a broad range interval, as Dr. Kolbe explains. “We had already a client whose annual lens consumption suddenly increased from 4 to 20 lens units. We have initiated an inquiry and found out that our client employed a new technician which did not install and tune the lenses as accurate as his predecessor.”

This effect is also evident in the other direction, training of the technical personnel by Ophir Optronics in more competent handling of the lenses decreases annual lens consumption from 20 units to four units. Dr. Kolbe advises, “I would advise each and every user to handle his lenses very carefully, to install them accurately, and to clean them occasionally. It is definitely worth it.”

This is valid in particularly for modern systems with higher laser outputs. For today’s outputs of 5 kW or more, a low concentration of contamination, even if not visible with naked eyes, can already have implications on the lens's performance, whereas previously for outputs of 1 kW or 1.5 kW the lens could function properly also in the existence of massive amounts of contamination.

Despite the higher requirements on the lenses the lifespan of the lenses did not become shorter, as one might expect, but actually lengthened. Dr. Jürgen Kolbe says, “cleaner beam lines and improvements in the process control lead to a much higher lifespan than was previously achievable. Process control faults such as a late inlet of the cutting gas which results in residues that reach and damage the lens belong since long ago to the past.”

Yet particles on the lens surface are, like before, an important factor which reduces lens lifespan. Despite the high-pressure cutting gas flowing in the opposite direction through the manufacturing tube, deposition of residual particles on the lens cannot be completely avoided. Such particles have the following effects: although not more than 0.1 mm in size, these undesired residues have a higher absorption rate which leads to a localized heating in the lens, and consequently to a local structural deformation. The deviation from the ideal lens shape shifts in turn the focal length.

Various other causes of failure of lenses which were the order of the day are no longer a factor to consider with modern laser-cutting systems. This includes contaminations which reside in the radiation ways and cause an erroneous focusing of the laser radiation on the lens as well as double refraction due to incorrect installation with linked wiring.

The advent of new system and lens technologies have not only diminished the importance of the old pitfalls, but also opened up new prospects, for example, the development of the Clear Magic lens. Although the Black Magic lens, developed about ten years ago, already offered a quite long lifespan and absorption rate of only 0.15 percent, its users had to face its major disadvantage: it is black and hence not transparent to light in the visible wavelength. It is therefore not suitable for use as red aid-laser, commonly used for laser positioning purposes in 3D processing, indicating the location of CO_2 beam-spot location on the component.

Moreover, it is also not suitable for process-control methods in which a sensor located in the radiation tubes is measuring and analyzing the light emitted from the processing point. With the development of the Clear Magic lenses, these disadvantages now belong past, and on top of that the absorption rate was reduced to just 0.13 percent.

In light of the recent advancements, the possibility of lens utilization also in laser-welding is increasingly attracting interest. The laser outputs typical for welding applications are usually so high, that lens focusing was previously impossible, and one had to resort to parabolic reflectors. Due to the complicated mechanics which are involved with them, the suitable processing heads are much more expensive than their lens counterparts. It follows that in many applications, the use of the new Clear-Magic lenses has led to considerable reduction in costs.

The new proficiency in higher laser outputs leaves all options open also in the field of laser cutting. Dr. Kolbe is uncertain, if this will in fact bring new applications: "In recent years an emphasis has been put on reaching higher and higher outputs. Every year or two, one extra kilowatt was achieved. It is, however, very hard to predict

whether this will be the case also in the future. But users' comments that, "We do not need these high outputs at all" are becoming more and more frequent, I am therefore not sure, that we will live to see outputs of 10 kW or more in regular use for cutting. Nevertheless, if outputs of 10 kW or more become necessary, it will not be the lenses that stand in the way.

Ophir Optronics

Ophir Optronics was founded 33 years ago in Jerusalem, Israel. The company also manufactures sensor heads and CO_2 optics. The company has about 450 employees worldwide. Apart from high-performance laser measurement systems, it manufactures above all optical products for infra-red applications, including, most recently, at its branch in the United States. Their most important products are cutting lenses, which enable one to focus the laser radiation on the machined part. The lenses put Ophir Optronics on par with the most renowned laser-system makers on one hand, and are also reputable among users in Germany and Japan, which are supervised by their own establishments.

The raw materials are purchased only from leading American manufacturers. The entire mechanical processing, coating and packing of the optical products take place in a clean room in Israel, in order to minimize the risk of contamination.