Absorption, Thermal Lensing, and Clear Magic

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During laser operation with several kilowatts, the focusing lens is heated because it absorbs a small portion of the laser power. The anti-reflection (AR) coating was developed for CO_2 lenses many years ago when lasers were lower powered than they are now. They were the best coatings available for many years. Now, of course, the average laser machine is no longer 1K to 2.5K, but can be up to 5 or 6K or more. These equipment improvements required that new optical coatings be developed to handle the thermal demands of higher power.

Absorption takes place mainly in the AR coatings or because of dirt on the lens. A brand new, clean lens with standard AR coating typically has absorption of 0.2% of the incoming laser power. A CO_2 laser lens, such as Ophir's Black Magic™, is a low absorption lens (lower than 0.15%). During use in a CO_2 laser cutting machine, absorption rises gradually due to increasing amounts of dirt on the lower surface. When the lens needs to be replaced, absorption usually is in the range 0.3 to 0.4%. The best coating for a CO_2 lens in the industry is Ophir's Clear Magic™. This coating is guaranteed to be lower than 0.13% absorption.

When a laser is cutting it creates heat, which causes additional surface curvature due to thermal expansion and increases the refractive index of the lens material (ZnSe). As a consequence of these effects, the lens focal length becomes shorter and the focus position cannot be predicted exactly because it depends on many parameters, like laser power, intervals laser on/off, cleanliness of lens, and others. Simply put, the heating of the lens causes it to change its shape. Not by a huge amount, but enough that you sometimes have to refocus the lens that was cutting just fine when you started.

One benefit of the newer, low absorption Clear Magic coated CO_2 laser lens is that it can make the focal length more stable and therefore improve reliability of the cutting process.

If there are dirt particles on the lens, the lens material is not heated uniformly, but mainly at the areas close to these dirt particles. As a consequence, focusing properties become worse; focus diameter increases, and cutting quality decreases. So if a certain "critical" amount of dirt has accumulated on the lens, it needs to be replaced. However, it might still work fine at reduced laser power.

Your next step is to clean off the nitrogen residues on the lens. The best method that has been found for cleaning nitrogen build up is to use alcohol or ethanol for the first cleaning wipe, then use white vinegar for the second cleaning pass, and finally another cleaning with alcohol or ethanol. This method should not be

used every day because although it is not abrasive, it is harsher than just plain alcohol and is in fact more severe on the coating. The key to this cleaning process is to let the lens completely dry between the different cleanings.

So, clean with alcohol or ethanol and let thoroughly dry. Then clean with distilled white vinegar and let dry. This is where the coating is the most vulnerable. This is the layer of cleaning that if put with alcohol or ethanol can compromise the coating. It is the combination of the two liquids together that can damage the coating.

When the lens is dry, use the alcohol or ethanol to clean off the residue from the vinegar. When the lens is clean and dry, you put it back into the machine and it will work fine. Ophir uses the best quality piece of Zinc Selenide that is available and uses high tech machinery to shape and polish it to the OEM specification.

Ophir has been a leader in developing specialized coatings in both CO_2 and infrared optics for over 40 years. Ophir CO_2 coatings protect the optic. The end user's job is to protect the coating. The length of life of the coating determines the life of the lens. This is the real protection from thermal lensing. A quality coating that is cared for meticulously will thereby, extend the life of the coating and in turn extend the life of the lens.