SUNSTAR传感与控制 http://www.sensor-ic.com/ TEL:0755-83376549 FAX:0755-83376182 E-MAIL:szss20@163.com

Electro Optical Components, Inc.
5460 Skylane Boulevard, Santa Rosa, CA 95403
Toll Free: 855-EOC-6300
www.eoc-inc.com | info@eoc-inc.com

Click to go to Product Selector

The behavior of optics at high power

Mark Wilkinson

Laser Beam Products Ltd

Stratton Park Dunton Lane Biggleswade Beds SG18 8QS

T: +44 1767 600877 F: +44 1767 600833 E: sales@lbp.co.uk

Any serious optical manufacturer should have the ability to measure all the optical properties of a lens or mirror before sending it out to a customer. Modern optical test equipment provides sub micron measurements (nanometres are an everyday unit of measurement in today's optical manufacturing) and at LBP, for example, we will often have measurements and test equipment independently verified at the National Physical Laboratory to ensure accuracy.

We suspect though, from parts returned to us for repair or identification, as well as from other clues from customer observations, that the properties of an optic in use can be quite different from those so carefully measured in the optics' manufacturers nice, clean, cool test facility. Could it be that we have been wasting our time and money?

A Zinc Selenide window

IFSW Stuttgart have reported real results and software predictions, on how a transmissive element behaves in a laser, rather than on a test bench.

Figure 1 shows the temperature profile of a window in a 1800W CO_2 laser. The window is 38mm diameter, and here a radial section from the centre, to one of the edges is shown. The vertical lines are isotherms (points of equal temperature) and describe the temperature variation across, and through the window. The window has an uneven temperature gradient from 20 degrees at the edge, to 33 degrees or so in the centre.

This variation in temperature has two effects. Firstly, the refractive index (or focussing power) of the material varies with temperature giving a variation in optical power. Secondly, the window or lens physically "bulges" in the centre, and this also changes the optical properties. The question is: is this temperature gradient significant?

Optical distortion

It is possible to measure the optical distortion caused by this unavoidable heating, but sadly impossible to interpret the answer in terms of X% slower cutting, or Y% reduction in edge quality. For physicists, the distortion is expressed as 4 µm of Optical Path Difference (OPD). For everybody else this can be though of as around 10 times worse than a typical manufacturing tolerance or 20 times worse than a 5" f.l plano/convex lens in a test environment.

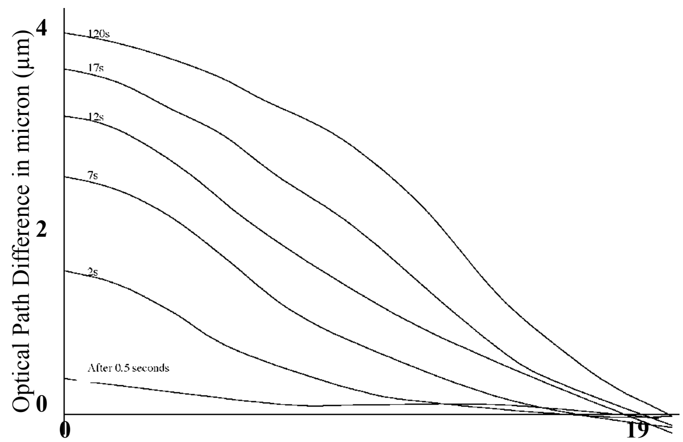


Figure 2. Timescale of distortion. The curves show the OPD across the ZnSe lens at different times under the conditions in figure 1, from 0.5s to 2 minutes.

Many readers will have seen the incredibly fine and razor sharp cutting performed by low power (5 – 50 Watt) CO_2 lasers. So I would like to pose the question: how much of this is due to the better beam quality inherent in these low power lasers and how much is due to the negligibility of heat-induced optical distortion?

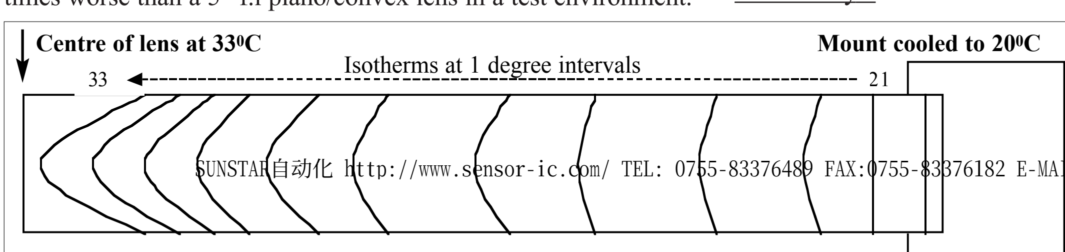
Time scale of distortion

Figure 2 shows the growth of optical distortion with time. Each curve gives the OPD (our chosen measure of distortion) after 0.5 seconds from turning the beam on, for the first 2 minutes. It shows that it takes 20 – 60 seconds for the window or lens to "settle down" to a steady state.

I'm sure this "thermal inertia" effect is familiar to many laser users. How often have readers found their initial set up is fine, only to see the cut drift off during the first few metres of cutting?. Or perhaps, when making mode checks, had a suspicion that the beam profile changed over the burn duration. Those who like to take a "hot burn" and a "cold burn" to distinguish whether the laser was running some time before the burn, clearly have a point.

It should be noted that mirrors will have a completely different behaviour with regard distortion and to "thermal inertia" time scale. This will be the subject of another article.

And finally...



More than 10 years ago there was an old wives tale that flat laser optics should be manufactured quite a bit concave from the desired specification, to offset the effect of distortion due heating in use. Like most old wives tales there is more than a

SUNSTAR自动化 http://www.sensor-ic.com/ TEL: 0755-83376489 FAX:0755-83376182 E-MAIL:szss20@163.com