Lens Condition Analysis

Exploring lens failures and their causes

INTRODUCTION

We have gathered our customers' feedback to bring you the following cases in lens condition analysis, capturing their experience in operating their laser systems:

Lens spatters

When analyzing a lens failure, we distinguish between the upper side – CX and the lower side - Plano/CC:

A. Upper side (CX) - normally caused by contamination originating from the machine side. Common types of contaminations include:

- Unsealed Beam Delivery system (holes in the bellows). This allows small particles to get into the Beam Delivery system, where they can land on top of the lens and cause uneven heat distribution.
- Oil/liquid contamination due to blocked filters, air separator etc.

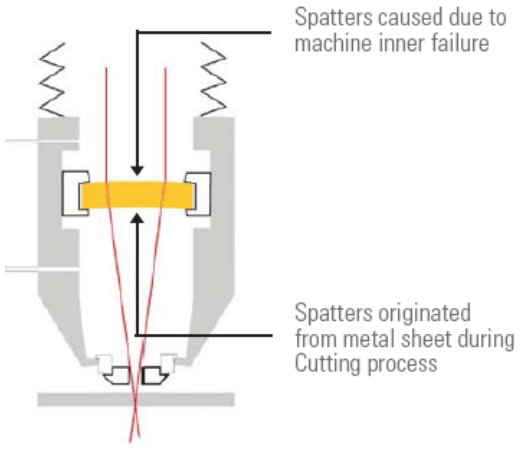

Fig. 1. Potential lens spatters illustration

B. Lower side (CC/ Plano) - this type of failure is usually caused by the following reasons (see fig.2):

- Incorrect piercing pressure (too low), especially when cutting with nitrogen
- Piercing too close to the surface of the plate
- Lens not in focus / inadequate cutting speed
- Metal sheet quality - mainly rust
- Low assist gas pressure
- Thermal lensing caused by material stress, scratches on the lens surface, metal spatters etc.

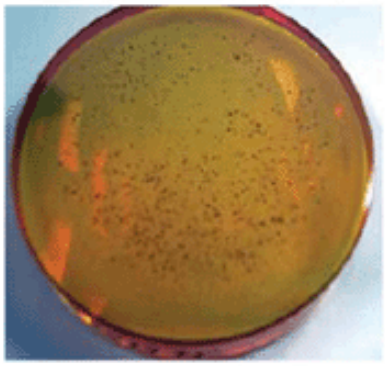

Fig. 2. Spatters on the bottom of the lens
Metal spatters diffuse the laser beam, causing poor cutting quality and reduced lens life time.

Lens cracks

A. Star shaped cracks

Uneven heat distribution of a focusing optic will frequently cause a star shaped fracture (see fig. 3).

Common causes of uneven heat distribution include:

- Laser beam interaction with metal spatters
- Uneven beam shape
- Inadequate lens cooling

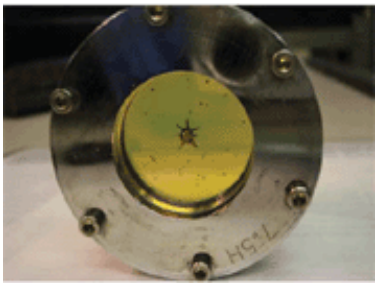

Fig. 3. Star shaped cracks caused by uneven heat distribution of a focusing optics

B. Lens cracks and burn marks

In this case, we see a massive crack occurring across the entire lens, followed by an uncentered burn mark covering the lower left area of the CX side of the lens (see fig. 4).
This type of burn is common in a Beam Mode failure; the distorted mode can generated a massive amount of energy, concentrated onto a small spot on the lens, leading to a lens explosion.
In most cases, incorrect beam mode occurs because of mirror misalignment, or failure in the beam delivery cooling system.

Fig. 4. Massive lens cracks, burn marks due to Beam Mode failure

C. Lens cracks - beam alignment failure

- Beam not parallel through one or more axes, striking the lens holder
- Beam mark not centered
- Failure occurs rapidly

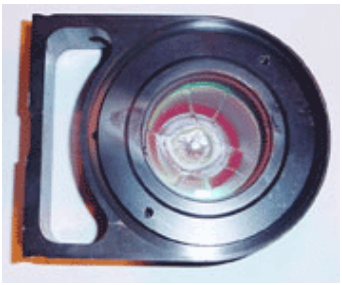

Fig. 5. Lens cracks due to beam alignment failure

Lens contamination

This type of failure was initiated in a top down direction, extending a hole completely through the center of the lens (see fig. 6). Brown residue and “rainbow” coloration on the side indicates the presence of petroleum products on the surface of the lens.
The optic failure in this case is a direct result of contaminated beam delivery purge air. Oil residue on top of the lens absorbed a significant amount of laser power, causing an uneven heat distribution (hot spot) which led to lens explosion. It is possible that the source of this contamination is from the compressor that pressurizes the beam delivery system.

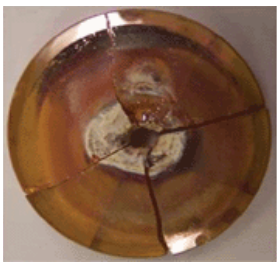

Fig. 6. Lens hole and coloration caused by oil contamination

Chipped or scratched lens edges

A defective lens mount will generally place a great deal of stress on the edge of an optic (see fig. 7). These stresses will be visible in the form of chipped edges or scratches along the perimeter. Common causes of mount defects include:

- Metal burrs on machined surfaces
- Contamination (metal particles) in the mount
- Indium wire not properly seated

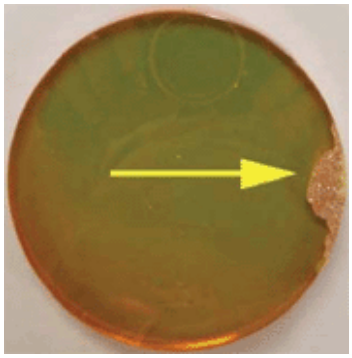

Fig. 7. Lens edge chipped due to a stress caused by a defective lens mount

Mirror contamination

Black discoloration proceeding towards the center may indicate a water leakage from the mirror mount, evaporating coolant in the beam path, or moisture in beam purge (see fig. 8).

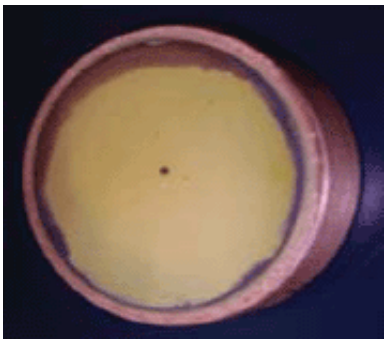

Fig. 8. Mirror with black discoloration

Loss of lens coating

Probable causes (see fig. 9):

- Improper cleaning (may have residue)
- Wrong or poor quality cleaning supplies
- Overly aggressivee cleaning (also causes scratches)
- Poor quality lens

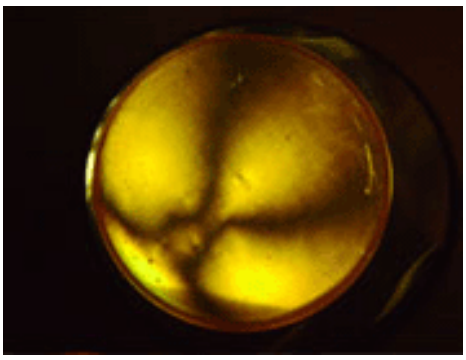

Fig. 9. Loss of lens coating

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