Spot Size and Effective Focal Length Measurements for a Fast Axial Flow CO_2 Laser

Robert J. Steele
Naval Air Warfare Center
China Lake, California 93555-6100

Phillip W. Fuerschbach
Danny O. MacCallum
Sandia National Laboratories
Albuquerque, New Mexico, 87185-0367

Abstract

An evaluation of the variation in focal plane position and spot size for a 1650 W fast axial flow CO_2 laser was performed. Multiple measurements of the focused beam were taken at stepped intervals along the beam axis to create a composite representation of the focus region. Measurements were made at several power levels from low to full power for each of five nominally identical lenses. It was found that as laser output power increases, the minimum focused spot radius increases, and the position of minimum focus shifts toward the laser resonator. These effects were attributed to observed variations in the diameter of the beam entering the focusing lens. For the ZnSe (f = 127 mm) lenses examined, variations in spot radius and focal plane position were seen. Lenses with high rated absorption had a larger variation in spot size and effective focal length than those with low absorption. Lenses that had previously been degraded by welding had the greatest variation.

Introduction

Accurate knowledge of the characteristics of a focused laser beam is critical for process control of laser beam welding and cutting. These characteristics include focused spot size, focal plane axial position, and depth of focus. In a job shop or laboratory environment, processing requirements can lead to frequent changes in laser set up conditions (such as output power or lens focal length) which, in turn, may lead to changes in the focus characteristics. In order to build process models, accurate values of spot size and focal position are required.

Other laser system related conditions are thought to have an effect on focusing as well. Heating of the output coupler from the resonator cavity is reported to cause distortion of the optic and affect the output laser beam. What effect does the surface condition of the lens have on the focusing characteristics? Focus lens condition is thought to be critical to the stability and repeatability of focus. Lens damage from weld vaporization and spatter, for example, may have an effect on the focused spot size. In addition to causing refractive effects, this damage may lead to lens heating and lens distortion.

This study is an evaluation of the focusing characteristics of several 127 mm focal length, plano convex, ZnSe lenses. Due to manufacturing tolerances, focusing lenses are produced with different values of absorption. A variation in focusing characteristics due to absorption might be expected. The repeatability of focusing characteristics for multiple nominally identical focusing lenses was also of interest.

Experimental

The laser used for this experimentation was a Rofin Sinar 1200SM fast axial flow CO_2 capable of producing up to 1650 W. The output coupler had been in the laser for less than 2 years and had less than 100 hours use time. Focus lenses were evaluated at 7 power levels from 200 to 1600 W.