A. Beam Profiling Of A 3.3kw CW Nd:YAG Laser

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Introduction

Replacement of electron beam welding with fiber-delivered laser welding is being considered for joining of nuclear materials. Remote location of the laser limits problems with potential radioactive contamination of equipment and provides for easier maintenance since workers are not exposed to radiation. Accurate characterization of the spatial profile of the laser beam used in these applications is mandatory for quality control purposes. The goal of this work is to develop a procedure for characterizing the beam profile of a continuous wave (CW) 3.3 kW Nd:YAG laser.

Technical Approach

The laser used in this study was diode-pumped, CW laser from Rofin-Sinar with a maximum power of 3.3 kW. The beam was delivered to the beam handling optics at the workstation by a 400 um diameter, stepped-index fiber optic. The beam was focused using objective lenses with either an 80 mm or 160 mm focal length. Several aspects of the spatial profile of the laser beam were determined using the Focus Monitor device of a beam profiling system manufactured by Precitec, Inc. Beam profile data was determined for both objective lenses at powers ranging from 500 W to 2.5 kW.

Results/Discussion

Aspects of the beam spatial profile measured in this study included minimum spot size at sharp focus, z-position of sharp focus and Rayleigh length as well as the x and y cross-section profiles at several z-planes and the averaged caustic profile. At lower powers for both lenses, the cross-section profiles were not symmetric and showed several “hot-spots”. The profile showed several distinct peaks with deep nulls along the x-axis and a greater number of peaks and nulls along the y-axis. The number and depth of the nulls decreased as beam power was increased. However, the number of peaks and nulls was always greater along the y-axis.

As expected, the minimum beam radius and Rayleigh length for the 160 mm lens were greater than those for the 80 mm lens. For the 160 mm lens, the minimum beam radius at sharp focus first decreased then increased (165 to 172 um) as power increased. The minimum beam radius at sharp focus for the 80 mm lens continuously decreased (84 to 87 um) as power increased. For both lenses, the distance from the lens to the minimum radius decreased as power increased. For the 160 mm lens, the Rayleigh length decreased then increased (1.57 to 1.69 mm) as power increased. The Rayleigh length for the 80 mm lens changed very little (0.43 to 0.44 mm) as power increased.

Sensor saturation level was found to have a strong effect on measurements. The saturation level should be carefully monitored during testing to ensure good data. The level should fall between 20% and 80% for accurate measurements. The sensor gain level should not be changed for comparative measurements. The probe tip and sensor can be damaged by beam powers ≥ 3 kW. Use of gas cooling is recommended at all power levels.

Conclusions

Procedures have been developed for accurate beam profiling of a CW Nd:YAG laser using the Precitec Focus Monitor. This Focus Monitor is a capable device but has subtle features not documented in the manual that strongly impact measurement accuracy. Gain settings and sensor saturation levels should be closely monitored during testing. Several aspects of the beam spatial profile were determined, and the beam was found to be asymmetric. The beam displayed “hot-spots” characteristic of a multi-mode laser. As expected, the minimum beam radius and Rayleigh length for the 160 mm lens were greater than those for the 80 mm lens.