

B. Distortion Testing and Analysis in Laser Welds

by C. V. Robino, F. M Hooper, M. Reece, J. D. Puskar, Sandia National Laboratories

Introduction

The selection of laser welding process parameters for critical applications requires consideration of a large number of factors, including: penetration, heat flow and thermal constraints, distortion, appearance, and productivity. Of these, one of the most difficult to analyze quantitatively is weld distortion. Although sophisticated numerical models of distortion are continually increasing in fidelity and utility, resource and time constraints often preclude their use. Recent work has shown that unrestrained transverse angular and shrinkage distortions in laser welds can be assessed by using simple, cantilever beam experiments.

Procedure

In these experiments, a laser weld is made across the narrow dimension of a long rectangular beam, and the angular distortion is measured with a height gauge. Shrinkage distortion is measured with the aid of fiducial marks. Provided appropriate descriptions of energy transfer are incorporated, these measurements can be correlated over a wide range of welding parameters by adapting semi-empirical models originally developed for arc welding. In turn, these correlations provide a basis for first-order distortion estimates in laser welds.

Results and Discussion

In the present study, the distortions in unrestrained laser welds were examined in greater detail, and the experiments and analysis were extended to restrained welds. Time resolved observations of the angular distortion in unrestrained and partially restrained welds were made by using high speed video techniques, and provide a means for translating the results from cantilever beams to longer welds typical of real components. In addition to the final distortion measurements, the time resolved measurements also provide a means for validation of more sophisticated distortion models.

Distortion measurements of restrained welds using a similar cantilever beam approach were made following release of the restraining force, and allow for the incorporation of more realistic joint features, such as gap, into the assessments. A load cell was incorporated into some of the restrained tests in order to provide time resolved measurements of the residual stress accumulation. These restrained distortion measurements can be correlated to the unrestrained measurements, as well as the welding parameters by using analytical models and correlations established for arc welding in conjunction with conventional stress analysis methods.

Conclusions

Taken together, the restrained and unrestrained measurements and analysis provide a basic framework for estimates of distortion in laser welds. This approach is not intended to replace more detailed distortion analyses, but rather is intended to provide a first order estimation and process development tool.