Abstract

The work presented in this thesis deals with the modeling and analysis of laser bending or forming processes using finite element method, statistical regression analysis and soft computing-based methods. Initially, temperature distributions and deformation field in laser bending with both continuous and pulsed mode have been calculated using finite element simulations. Results have been validated through experiments and are found to be satisfactory. Statistical regression analyses and soft computing-based models have been developed for continuous and pulsed laser bending processes to predict the outputs and process parameters. Process parameters considered for continuous wave laser bending process are laser power, scan speed, spot diameter, number of scans and scan position, and those for pulsed laser bending are laser power, scan speed, spot diameter and pulse duration. Significant process parameters have been identified and their effects on the responses have been explained for both the cases. Optimizations of the laser bending processes have been carried out to obtain the maximum bending angle and corresponding set of inputs. Soft computing-based models of continuous laser bending process with multiple parallel laser scans have been also developed for process synthesis of forming a class of 2D surfaces and the developed models have been validated through experiments. Statistical regression analysis and neural network-based methods have been also used in the analysis of 3D laser forming process for forming a dome shaped surface. All the process parameters, i.e., laser power, scan speed and spot diameter considered are found to have significant influence on the response, dome height. Dome height is found to increase with the increase of laser power and decrease with the increase of spot diameter. However, dome height initially increases marginally and then decreases with the increase of scan speed. The scan speed is found to have an optimum value for the maximum dome height. The proposed methods are able to model the 3D laser forming process for estimating the dome height for a set of input process parameters and also to predict the process parameters in order to obtain a particular dome height. The prediction accuracy obtained by the developed models for both the forward and inverse analyses is found to be satisfactory.