Title of the Ph.D. Thesis: Forward and Reverse Modeling of Plasma Spray Coating Process: Experimental Observations, Statistical Analyses and Soft Computing-based Approaches

Abstract

The present thesis aims to model plasma spray coating process in forward and reverse directions. In forward modeling, outputs of the process have been represented in terms of the process parameters, whereas reverse modeling predicts the input parameters to be provided in order to get desired values of the responses. Four input parameters, namely primary gas flow rate, stand-off distance, powder flow rate and arc current have been used as inputs; and three responses, viz., coating thickness, porosity and hardness of coatings have been considered. Central composite design of experiment has been adopted in order to obtain the combinations of input parameters to conduct the experiments. Three levels for each of the input parameters are considered and each combination has been repeated three times for conducting the coating experiment. Statistical regression analysis has been carried out to get the influences of input parameters on the responses. Non-linear regression equations are obtained to represent the outputs as the functions of input parameters. Significance of each of the process parameters has been explored using significance test and analysis of variance (ANOVA) test on each of the responses has been conducted. Soft computing-based models have been developed using both fuzzy logic as well as artificial neural network-based techniques. Hierarchical structures of adaptive neuro-fuzzy inference system (ANFIS) modules have been implemented to predict the outputs, individually. Multilayer feed-forward neural networks and radial basis function neural networks are used to model the process. The concept of clustering is implemented in some of the proposed approaches. In this regard, fuzzy c-means (FCM) and entropy-based fuzzy clustering (EFC) algorithms have been used. Back-propagation algorithm (BP), genetic algorithm (GA) and particle swarm optimization (PSO) algorithm have been utilized for the purpose of optimization. The developed models are validated using some experimental cases. Hybrid approaches using soft computing tools are found to perform better than other developed approaches for the above purpose.

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