Abstract

Electron Beam Welding (EBW) process has wide applications in the nuclear and aerospace industries. The salient features of EBW process make it the most suitable amongst all the conventional and modern welding techniques. However, the high initial cost of the equipment and unavailability of the complete knowledge base related to electron beam (EB) welding of various metals and alloys are the most important factors, due to which, the said technology could not gain much popularity and remained confined to the strategic and space industries. Various components and equipment were designed assuming the non-availability of EBW technologies, which would have been designed otherwise in a more compact, efficient and economic manner utilizing the EBW process. The EBW technology available today has a very large dependence on the operator of the EBW machine. Therefore, an attempt is required to automate the EBW process, so that it need not remains operator specific. The input and output relationships of the EBW process must be known in both forward and reverse directions in order to automate the process and hence, to develop smart EBW machines with automated knowledge base system. The present thesis aims to model the EBW process in both forward and reverse directions using regression analysis and soft computing-based approaches. The systematic investigation was carried out for the EB welding of similar, dissimilar, and reactive metals according to a central composite design of experiments matrix. The non-linear regression analysis was carried out to investigate the effects of process parameters, viz., accelerating voltage, beam current and welding speed on the responses, such as bead profile in terms of weld bead width and depth, and mechanical properties in terms of yield strength and ultimate tensile strength. The neural network (NN)-based models were used to develop predictive models for the EBW process in both forward and reverse directions. The parameters of the NN were optimized using Back-propagation (BP) algorithm, genetic algorithm (GA) and particle swarm optimization (PSO) algorithm. The adequacy of the developed models was checked using some test cases. It was observed that NN-based approaches could model the input-output relationships of the EBW process for similar, dissimilar and reactive metals accurately in both forward and reverse directions. The training of the NN-based approaches was done off-line and once the training was over, these approaches could yield the outputs for a set of inputs within a fraction of second. Thus, these approaches were found to be suitable for on-line implementation.

Keywords: Electron beam welding; BPNN; GANN; PSONN; Dissimilar metal welding; Zircaloy-4; Forward and reverse mappings.