ABSTRACT

The aim of this study was to carry out experimental investigations on electron beam welding (EBW) of precipitation-hardened (PH) Cu-Cr-Zr alloys used as heat sink components in International Thermonuclear Experimental Reactor (ITER) and also spiking phenomenon in EBW of ETP copper plates. Experiments were conducted by following central composite design (CCD) and statistical regression analysis was carried out to correlate the input parameters, namely accelerating voltage, beam current, welding speed and focusing distance for EBW of Cu-Cr-Zr alloy plates, with the outputs. Five welding schedules yielding the higher hardness of weld were chosen and then, were subjected to standard metallographic and various microscopy techniques to reveal the type, morphology, and distribution of the precipitates and obtain the sub-structural information from the weld zone. X-ray diffraction studies revealed the predominant formation of inter-metallic phases in the welded zones of some of the samples, which could have resulted in higher hardness and better electrical conductivity compared to those of other ones. Microhardness values in the fusion and heat affected zones were found to be less than that of the parent material. The process parameters considered for studying spiking phenomenon are accelerating voltage, beam current, welding speed, focusing distance, frequency oscillations and amplitude oscillations. The main process parameters were identified for both the cases and their effects on the responses had been investigated. Optimization was carried out to ensure minimum weldment area after fulfilling the conditions of maximum bead penetration and minimum deviation of the hardness of fusion zone from that of parent material for EBW of Cu-Cr-Zr alloy. The spiking phenomenon was characterized in terms of average penetration and standard deviation of penetration. Similarly, for spiking phenomenon, optimization was carried out in order to maximize weld penetration and minimize standard deviation of penetration. These optimization problems were solved using Genetic Algorithm (GA), Particle Swarm Optimization (PSO) algorithm and desirability function approach separately. The optimized results were verified through real experiments and a good agreement between them was achieved. In both the cases, the GA was found to perform slightly better than other approaches.

Keywords: Electron beam welding, Cu-Cr-Zr alloy, ETP copper plates, microstructure, microhardness, X-ray diffraction, precipitate volume fraction, electrical conductivity, spiking phenomenon, optimization, genetic algorithm, particle swarm optimization, desirability function.