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A defect-responsive optimization method for the fiber laser butt welding of dissimilar materials

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Abstract

Laser butt welding (LBW) of dissimilar materials has received great attention in automotive, power, chemical, nuclear and aerospace industries. The quality of welded joints is significantly affected by the generated defects in the dissimilar materials welding process. This paper proposes a defect-reducing optimization method that considers the geometric features of weld bead as evaluation indexes of welding defects and process parameters effect on the responses. The former aims to reduce welding defects for welding operations, and the latter seeks to identify the extent of contribution of actual process parameters on welding defects. The particle swarm optimization and back propagation neural network (PSO-BPNN), which has proved to be good modeling for no-linear problems, are utilized to establish the mathematical model and the defects reduction objective is combined with weld area. The genetic algorithm (GA) is adopted to solve the model. The effect of significant factors on the responses is identified based on the calculation of signal to noise (S/N) ratio and analysis of variance (ANOVA). The proposed method is evaluated by macro weld profile, microstructure and mechanical properties in confirmation tests. The results show that the proposed method is effective at reducing weld defects for dissimilar materials welding in practical production.

Keywords: Laser butt welding; Welding defects reducing; BPNN; PSO; GA

1. Introduction

The demand for welded joints between dissimilar materials is continuously increasing in the advanced manufacturing industry requiring certain special combination of properties, such as the automotive, power, chemical, nuclear and aerospace industries. The products joined by different metals and compositions provide the designer and production engineer with

Abbreviations: LBW, laser butt welding; LP, laser power; WS, welding speed; FP, focal position; BPNN, back propagation neural network; PSO, particle swarm optimization; GA, genetic algorithm; S/N, signal to noise; ANOVA, analysis of variance; FZ, fusion zone; LD, longitudinal defects; BH, bead height; TD, transverse defects; WFL, left front width; WFR, right front width; WF, front width; WB, back width; T, thickness; HD, height difference; WD, width difference; HAZ, heat-affected zone; FAG, fine equiaxed grains.

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