PARAMETRIC OPTIMIZATION OF PERFORMANCE MEASURES OF WIRE ELECTRO-DISCHARGE MACHINING FOR TITANIUM MATRIX COMPOSITE

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Abstract

Conventional machining of hybrid titanium matrix composite (TMC) is very intricate due to its superior characteristics of corrosion resistance, superior strength-to-weight ratio, fatigue and abrasion resistance. It is expansively necessary for aerospace, bio-medical and automobile industries. In recent diverse modern multi-disciplinary industries like automotive, aerospace and biomedical there is a comprehensive usage of titanium matrix composite (TMC) for its exceptional strength and resistant properties. The prime scope of this investigation deals with the development of a novel TMC by laser engineering net shaping (LENS) process and recent state-of-the-art of advancement of tribo-mechanical and metallurgical properties like Young's modulus (550 GPa), co-efficient of thermal expansion ($8.6x10^{-6}$ /K), hardness (396 HV), yield strength in compression (945-1020 MPa), ultimate compressive strength (1020-1096 MPa) and elongation (25-32.5%). Laser process parameters like laser power (P), scan speed (V) and energy input/area (E) are varied. The microstructure and characterization depict an outstanding interfacial bonding between TiB_2 and Ti where the best parametric combination is identified. A novel optimization algorithm named as desirable genetic algorithm (DGA) is proposed in this research. The objective functions determined by desirability function are further incorporated in genetic algorithm in MATLAB R2018a to improve the optimized solution. Multi-objective optimization (MOO) is developed by Box-Behnken design (BBD) and mathematical model is projected considering response surface methodology (RSM) on output responses like cooling rate (CR) and hardness (H), and legitimated by confirmation tests. ANOVA is incorporated for seeking the contributing effects and significance of the parameters. Optimal solution achieved after DGA, when P is 350.956 W, V is 12.371 mm/s, E is 49.475 J/mm^2, CR is -3146515.795

K/s and H is 395.097 HV, and combined overall desirability is 0.838. Optimization is additionally enhanced by 20.049% of CR and 0.229% of H when evaluated with DGA.

Further the investigation deals with the development of another new-fangled optimization algorithm termed desirable grey relational analysis (DGRA) which is a combination of desirability and grey relational analysis. Here, the predicted responses obtained from desirability function are further analyzed with the experimental results obtained from WEDM by varying power (P), time off (Toff) and peak current (IP) which are regarded as chief input process parameters. Comparative analysis is projected by FTOPSIS along with FAHP for criteria weights between experimental and proposed MOO algorithm. RSM is conducted on BBD model (3 factor / 3 levels) DOE on output responses like material removal rate (MRR), surface roughness (SR), kerf width (KW) and over cut (OC). Satisfactory outcomes are obtained authenticated by confirmatory test. To obtain the significance of these models, ANOVA is again incorporated. Optimal solution is obtained by desirability approach to achieve the most excellent output responses which are additionally improved by 1.75%, 0.73% and 1.02% when contrasted with desirability to FTOPSIS, FTOPSIS to DGRA, and desirability to DGRA respectively.

Keywords: Laser engineering net shaping; Wire electro-discharge machining; Desirable grey relational analysis; Desirable genetic algorithm; Microstructure; Multi-objective optimization