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Empirical Modeling and Optimization of Laser Welding of AISI 304 Stainless Steel

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Abstract : Laser welding process is a capable technology for forming the automobile, microelectronics, marine and aerospace parts etc. In the present work, a mathematical and statistical approach is adopted to study the laser welding of AISI 304 stainless steel. A robotic control 500 W pulsed Nd:YAG laser source with 1064 nm wavelength has been used for welding purpose. Butt joints are made. The effects of welding parameters, namely; laser power, scanning speed and pulse width on the seam width and depth of penetration has been investigated using the empirical models developed by response surface methodology (RSM). Weld quality is directly correlated with the weld geometry. Twenty sets of experiments have been conducted as per central composite design (CCD) design matrix. The second order mathematical model has been developed for predicting the desired responses. The results of ANOVA indicate that the laser power has the most significant effect on responses. Microstructural analysis as well as hardness of the selected weld specimens has been carried out to understand the metallurgical and mechanical behaviour of the weld. Average micro-hardness of the weld is observed to be higher than the base metal. Higher hardness of the weld is the resultant of grain refinement and δ-ferrite formation in the weld structure. The result suggests that the lower line energy generally produce fine grain structure and improved mechanical properties than the high line energy. The combined effects of input parameters on responses have been analyzed with the help of developed 3-D response surface and contour plots. Finally, multi-objective optimization has been conducted for producing weld joint with complete penetration, minimum seam width and acceptable welding profile. Confirmatory tests have been conducted at optimum parametric conditions to validate the applied optimization technique.

Keywords : ANOVA, laser welding, modeling and optimization, response surface methodology
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