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Sensitivity analysis of flux cored arc welding process variables in super duplex stainless steel claddings.

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Abstract

Weld surfacing with super duplex grade stainless steel found to improve corrosion resistance and functional life of the mild steel components used in the process industries. The properties of the deposited layer were influenced by the process variables that affect the heat input to the process. The influence exerted by the process variables on the responses of super duplex stainless steel claddings were modeled using the response surface models. The response surface models developed by the regression techniques using the data collected from central composite rotatable design of experiments. The data extracted from 32 single bead on the plate welds were deposited by flux cored arc welding process. The developed models can be used to predict and simulate the influence of the process variables on the responses. The insignificant variables found in the full models were removed by the backward elimination technique. Sensitivity analysis performed on the reduced models helps to identify and rank the process variables based on their extent of influence on the responses. Then the ranked variables are closely regulated to tailor the properties of the surfaced layer.

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Keywords: FCAW; super duplex stainless steel; cladding; response surface; sensitivity; regression;

1. Introduction

The duplex grade stainless steel possesses two-phase microstructure of austenite and ferrite at equal proportions found to improve the strength and corrosion resistance properties. The stainless steels are difficult to process with

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conventional manufacturing techniques because of their properties increasingly dependent on the composition and microstructure [1]. The variation in the composition decreases the resistance against pitting and stress corrosion cracking in the aggressive environments exists in petrochemical, chemical, food processing, paper industries and desalination plants. Presence of chlorine ions in these environments accelerates the pitting and stress corrosion cracking. Weld surfacing is used in the fabrication and repair industries to increase the durability of the functional components used in the process industries [2]. The property of the surfaced layer depends on the percentage dilution, which is the amount of the base metal melted and mixed with the deposited electrode. The percentage dilution found to be influenced by the heat input which in-turn affects the composition, strength and integrity of the fused layer [3]. The adaptability of the weld surfacing stems from the fact that it can process semi-finished products and wide range of processes available to cater the needs of different industries. The flux cored arc welding (FCAW) process is a versatile process because of its portability, smooth bead appearance, all position and automation capabilities [4]. The influence of welding variables on the percentage dilution can be simulated using the second order mathematical models developed by using response surface methodology [5]. The developed models represent the important responses like percentage dilution, reinforcement height, etc., as a function of independently controllable process variables like welding voltage, wire feed rate, welding speed, etc., The validated models can be used to simulate direct and interaction effect of process variables on the responses as well as to study the sensitivity of the process variables on the responses [6–9]. The simulation of the weld cladding process provides significant savings in the man, machine and materials. The sensitivity analysis is used to assess and rank the effectiveness of the process variables on the responses [7, 8, 10]. The information gathered from the sensitivity analysis helps to identify the process variables to tailor made the properties of the fused layer to suit the requirements of the end user.

Nomenclature

X_1	welding voltage (Coded)
X_2	wire feed rate (Coded)
X_3	welding speed (Coded)
X_4	nozzle to plate distance (Coded)
X_5	welding gun angle (Coded)
R	response or dependent variable
$\beta_0, \beta_1, \beta_2 \cdots$	coefficients of the second order mathematical model
D	Percentage dilution in percentage
H	Reinforcement height in mm
W	Bead width in mm
SS	Sum of squares
DF	Degree of Freedom

2 Experimental investigation

The mathematical models were developed using the data collected from the five factors five level experiments based on the central composite rotatable design. The experimental investigation was carried out in the following steps.

- Identification of process variables and responses
- Establishing the range of process variables and coding
- Development of the design matrix
- Experimentation and data collection
- Mathematical model development
- Validation of the developed mathematical models