Experimental Study and Modeling of Gas Metal Arc Welding Process to Produce 5083-O Aluminum Alloy Butt Joint

Karuna Kanwar[*], Brijesh Prasad[*], Rajesh P. Verma[**]

Abstract

The proper modeling of welding processes and process parameters is very important to attain good mechanical properties of welded joint, which are directly or indirectly controlled by a number of welding parameters. A number of methods are suggested by researchers to model the fusion welding process. Among them Response Surface Methodology (RSM) is popularly used. In this research work, a statistical modeling of the gas metal arc (GMA) welding of 5083-O Al-alloys was done using RSM. The analysis considered three levels of three factors (welding current, voltage & gas flow rate) and two responses (tensile strength and weld hardness). The experimental design was based on central composite rotatable design with full replication. The results indicate that the proposed models predict the responses adequately as the percentage of error is in good agreement.

Keywords: **GMAW, Modeling, Response Surface Methodology, Aluminum alloy, Mechanical Strength.**

Introduction

Excessive heat input results in melting and distortion in welding. Process variables such as welding current, arc voltage, welding speed, gas flow rate and offset distance strongly affect the mechanical properties like weld bead geometry and microstructure. Because of melting and metal transfer phenomena in GMAW process, welding parameters behave nonlinearly and are complex to analyze.[1,2] Thus proper modeling of welding process and its parameters is required. One of the widely used methods to solve this type of problem is the response surface methodology (RSM). In this study, the tensile strength (TS) and weld hardness (WH) of GMAW 5083-O Al-alloys are investigated and modeling of welding parameters; current, voltage and gas flow rate, is made for superior mechanical properties of joint.

Methodology

Central composite design (CCD) was chosen as experimental design for the RSM optimization. Design expert software was used to code the variables and to establish the design matrix. Experiments were planned as per design matrix to evaluate responses and RSM was applied to the experimental data. Regression equations were obtained to obtain the best fit.

Experimentation

This work involves GMAW process of 6 mm thick 5083-O aluminum alloy plate with a right angled V- grooved butt joint of 2 mm root opening. A single pass welding process was used and the filler metal employed was ER5356. 99% pure argon (Ar) gas was used for shielding. In order to find the upper and lower values of the process input parameters, trial welding was carried out by varying one of the process parameters at a time. The ranges of welding current, voltage and gas flow rate were found 180-270 ampere, 22-30 volts and 14-24 lit/min respectively. Tensile properties of the weld joints were determined according to ASTM standards (B-557M) in the transverse directions and Vickers's micro- hardness testing machine was used for measuring the hardness of the weld alloy with a load of 500 g.

Conclusions

The design expert V9 was used to analyze the measured responses. The quadratic polynomial is

[*]PG Student, Mechanical Engineering Department, Graphic Era University, Dehradun (GEU), India
[**]Assistant Professor, Mechanical Engineering Department, Graphic Era University (GEU), Dehradun, India
E-mail Id: kanwarkaruna18@gmail.com

used for tensile strength in this work so that the effect of the combination of parameters can be studied; however it results into significant lack of fit.

In terms of actual factors:

$$TS = 38.5532 + 1.20152A - 1.90370B - 0.00351269A^2 \quad (1)$$

$$WH = -68.0561 + 1.03946A - 0.4367B + 4.20524C - 0.00248702A^2 - 0.11352C^2 \quad (2)$$

Perturbation plots show that welding voltage has slightly negative effect on tensile strength and weld *hardness. The responses increase with the welding current, till it reaches its center value, and then drops.* The results demonstrate that the models developed are quite accurate as the percentage error is < 10%.

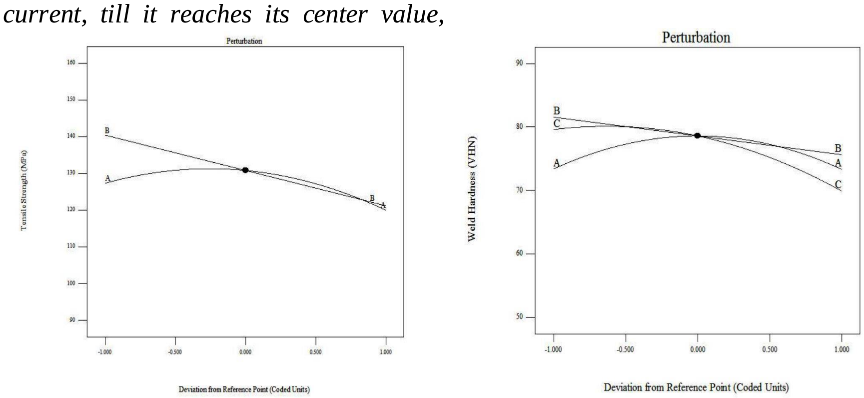

Figure 1.Perturbation plots showing the effect of significant factors on the TS and WH

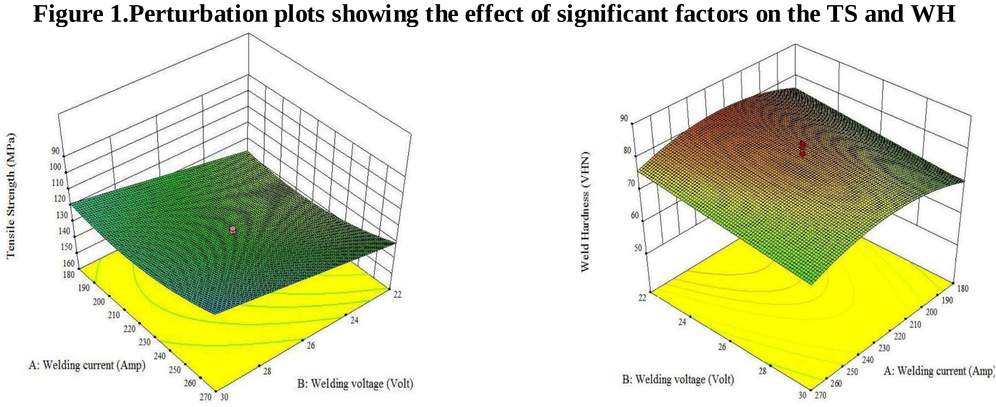

Figure 2.3D graph of effect of A and B on TS and WH

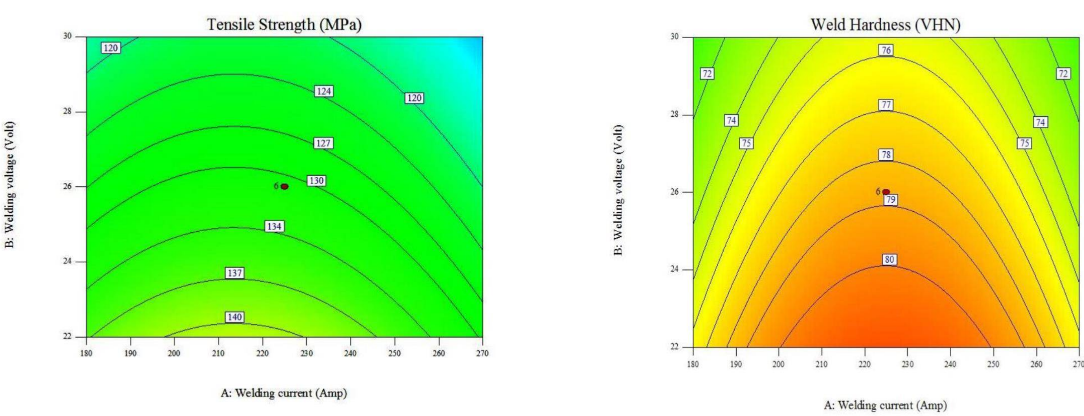

Figure 3.Contour graph of effect of A and B on TS and WH

References

1. Padmanaban G, Balasubramanian V. Optimization of laser beam welding process parameters to attain maximum tensile strength in AZ31B magnesium alloy. *Optics & Laser Technology* 2010; 42: 1253-60.
2. Khan MDF, Dwivedi DK, Sharma S. Development of response surface model for tensile shear strength of weld-bonds of aluminium alloy 6061 T651. *Materials and Design* 2012; 34: 673-78.
3. Kumar A, Sundarrajan S. Optimization of pulsed TIG welding process parameters on mechanical properties of AA 5456 Aluminium alloy weldments. *Materials and Design* 2009; 30: 1288-97.