Linear Regression analysis with one parameter for the Estimation of Proof Stress for the TIG welded Al-65032

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Abstract: regression analysis is an useful tool to establish relation between various input parameters and output parameters. The material properties of a weldment in TIG welding depend on welding parameters like shielding gas pressure, current, torch angle, electrode size, electrode projection, arc length etc. It is also influenced by the joint parameters like groove angle, land, root gap, preheating temperature. But a lot of noise parameters like variation of base material properties, variation in quality of inert gas used, variation in ambient conditions, variation in workman ship etc introduce the variability into the process. In the present work a linear regression analysis is carried out to predict Proof Stress of TIG welded Al-65032 with the variation of four parameters namely inert gas pressure, current, groove angle of the joint and preheating temperature of base metal one at a time. To minimise the no. of experiments in designing data base an L-9 orthogonal array is chosen for experimentation.

Key words: Orthogonal array, Linear regression, TIG welding, Al-65032

I Introduction

Regression analysis is a set of statistical methods used for the estimation of relationships between a dependent variable and one or more independent variables. The mathematical groundwork of regression analysis was laid in the first decade of the nineteenth century by Adrien-Marie Legendre and Carl Friedrich Gauss, who separately described the method of least squares and applied it for the calculation of orbits of celestial bodies. Since then, both the mathematical complexity of regression techniques and their applications to almost all fields of scientific inquiry have greatly evolved. A brief review of the regression analysis used in neurosurgery was discussed by Dana Pisaca et.al [1]. Multi-output regression analysis model was developed and implemented to simultaneous output variables, ground water and lake water levels taking the Urmia lake case study by Mir Jafar Sadegh Safariet.al. [2]. Josmar Mazucheli [3] applied parametric and nonparametric quantile regression to biomedical data of Brazil, Kovid 19 data of US. Vivian W.Y. Tamet.al [4] used regression analysis for prediction of compressive strength of CO2 concrete. Vladimir Konecnya et al. [5] carried out multi criteria regression analysis to identify the demand for bus transport in Ceske Budejovice, Czech Republic with the variation of independent parameters like Fare, Income of the population, Supply of connections, Quality of transport, Car ownership. Rail steel wear analysis is carried out by Jinlong Wang et.al [6] using vector regression analysis. Inna N. Ponomareva [7] described the method of finding the formation pressure by using multidimensional multivariate analysis of the actual reservoir data from the Sukharev field with several operational, geological, and reservoir properties at various stages of the field pressure . Xingping Hana et.a.l [8] used meta-regression analysis on prognostic significance of pre-treatment systemic hemato-immunological indices of cervical cancer patients. Balazs Miko [9] assessed the flatness error by regression analysis. Jamiu Oyekan Adegbite et.al [10] established relationship among the porosity, permeability and pore throat size of transition zone samples in carbonate reservoirs using multiple regression analysis. Mohamed Mahmoud Ali et.al [11] Predicted the correlations between hardness and tensile properties of aluminium-silicon alloys produced by various modifiers and grain refineries using regression analysis

The mechanical properties of the weld joints are much lower than that of the base materials because of the nonuniform heating and cooling temperature filed applied in the welding processes [12] . So parametric studies on mechanical properties of weld specimens are essential for particular metal with a given process. Al-65032 is a precipitation hardening aluminium alloy and one of the most common alloys of aluminium for general purpose use. Aluminium alloys are difficult to weld materials. In the manufacturing process of Aluminium alloy components, tungsten inert gas (TIG) arc welding is still the dominant joining method due to its flexible operation, high production efficiency and good weld formation [13]. TIG welding process is influenced by number of parameters

individually and combinedly with a high complexity of interactions. The complex interaction of the parameters result into a wide variation in the weldment properties, geometry, and metallurgical features. In the current work a linear regression analysis is carried out to find the relation of proof stress of TIG welded AL-65032 specimen with gas pressure, current, grove angle, preheating temperature, one at a time.

II. input Parameter selection

Table 1: The input variables

. S.No	Input Parameter	Level 1	Level 2	Level 3
1.	Pressure (KPa)	104	125	139
2.	Current (Amps)	145	150	160
3.	Groove angle (Deg)	45	60	70
4.	Pre-heating (^{O}C)	125	150	175

The input variable selected are pressure, current, groove angle and preheating. for reducing the no. of experiments an orthogonal array L-9 is selected for experimentation. Experiments conducted with the Taguchi Orthogonal arrays will give the reasonably accurate results even in partial factorial case. So in the current work the validity of this hypothesis is tested.
The three levels of the parameters selected after preliminary experiments are given in table 1. With four parameters and three levels Orthogonal array L9 was selected for the experimentation and the levels of the parameters shown in table 1 are assigned to the OA and presented in table 2.

III. Experimentation

Standard test pieces with dimensions 150mm X 150mm X 6mm are cut from the Al-65032 alloy sheet are prepared with a saw machine. The plates are grooved to the desired angle on a milling machine. The milled pieces were engraved with a specific number for identification. The pieces were pickled. Hydrochloric Acid is used for the process. A ready to weld sample of weld specimen is presented in Fig 1 and the test pieces are shown in Fig2. Experiments are conducted on welding machines presented Fig 3.

Table 2: OA after assigning the values

Run	Pressure (KPa)	Current (Amps)	Groove angle (Deg)	Pre-heating (OC)
1.	104	145	45	125
2.	104	150	60	150
3.	104	160	70	175
4.	125	145	60	175
5.	125	150	70	125
6.	125	160	45	150
7.	139	145	70	150
8.	139	150	45	175
9.	139	160	60	125

The tensile test was carried out. The UTS values for various trials are presented in Table 3. For all the parameters output values at the levels 1,2,3 are summed up and averaged. The averaged values are presented in the table 3 against A1, A2 and A3 and the values are plotted in Fig 4 to know the variation.

Fig 2: Tensile test samples

Table 3: Ultimate Tensile strength values for various trials

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Run	Pressure	Current	Angle	Pre-heating	Proof Stress (MPa)
1	1	1	1	1	102.7
2	1	2	2	2	115.2
3	1	3	3	3	114.9
4	2	1	2	3	113.8
5	2	2	3	1	113.1
6	2	3	1	2	114.9
7	3	1	3	2	122.5
8	3	2	1	3	110.4
9	3	3	2	1	115.2
A1	110.93	113.00	109.33	110.33	
A2	113.93	112.90	114.73	115.53	
A3	116.03	115.00	116.83	113.03	

IV Regression Analysis

a single variable linear regression analysis is carried out to identify the effect of each variable independently to understand the effect of each variable in isolation. Matlab is used to carry out the single variant regression analysis. Fig 4 shows a scatter plot of the variation of Proof stress with gas pressure. A linear curve is fitting is done with Matlab and linear regression equation is found out to be

Proof stress (in MPa) = 0.1455 * Pressure (in KPa) + 95.78

It is also observed that there exists a slightly positive correlation between proof stress and gas pressure.

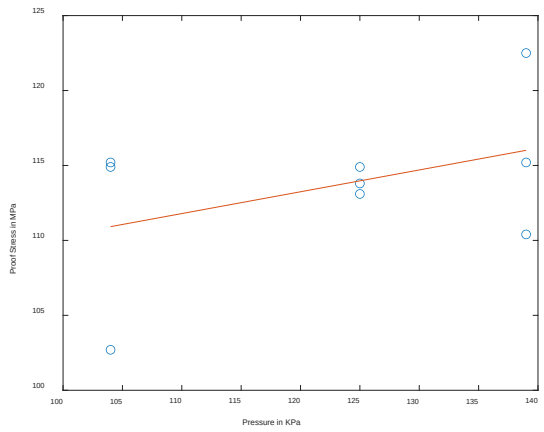

Fig 4: Variation of Proof Stress with the variation of gas pressure

Scatter plot between Proof Stress and current is plotted and shown in Fig 5. It also shows slight positive correlation between Proof Stress and current. But the influence is lesser than that of gas pressure.The corresponding regression equation is found out to be

Proof Stress (in MPa) = 0.1433* Current (in A) + 91.75

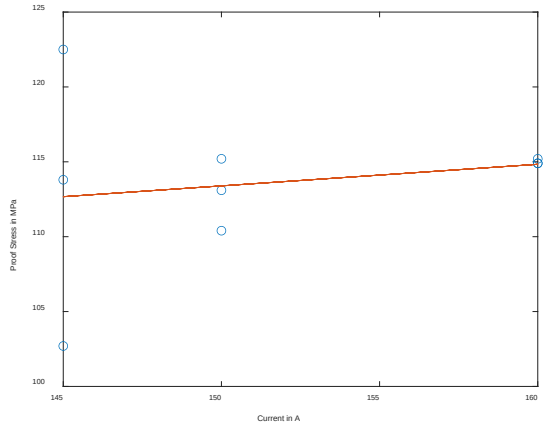

Fig 5: Variation of Proof Stress with the variation of current

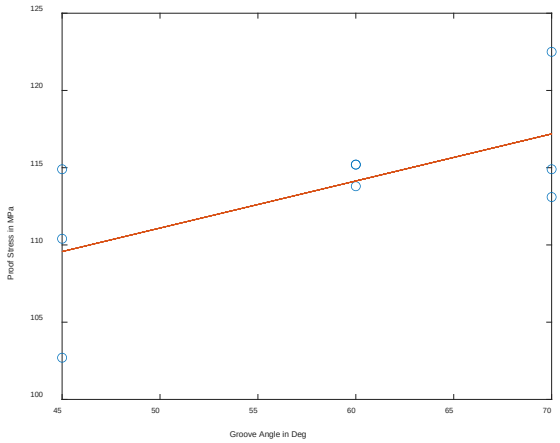

Fig 6: Relation between Proof Stress and grove angle

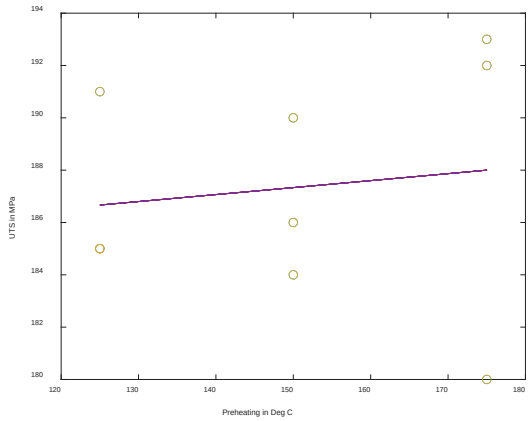

Fig 6: Relation between UTS and preheating temperature

From Fig 6, it is observed that there exists a strong positive correlation exists between UTS and preheating temperature with the linear regression equation given bellow

Proof Stress (in MPa) = 0.3047 *Groove angle + 95.86

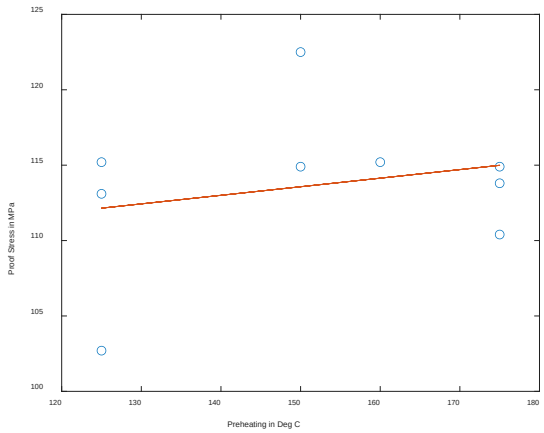

Fig 7: Relation between Proof stress and preheating temperature

From Fig 7, it is observed that there exists a slight positive correlation exists between proof stress and preheating temperature with the linear regression equation given bellow

Proof Stress (in MPa) = 0.0568 *Preheating (in Deg C) + 104.05

The slopes of regression equations are observed to be 0.1455, 0.1433,0.3047 and 0.0568 for gas pressure , current, groove angle and preheating temperature respectively which indicates that groove angle has predominance over other two factors

VI Conclusions

In the current work a single variable linear regression analysis is carried out to identify the effect of gas pressure, current groove angle and preheating temperature on proof stress of TIG welded AL65032 alloy. Linear curve fitting is done and the relations are obtained. The following points were observed during the study.

- All the selected variables i.e gas pressure, current, groove angle and preheating have positive correlation with the proof stress.
- Out of the parameters groove angle has highest influence on the proof stress of the material.

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