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OPTIMIZATION OF WELDING PARAMETERS OF A633 GRADE E STEEL ON STRENGTH OF BUTT WELD JOINTS USING TIG WELDING

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***Abstract*: -** Welding is the metal joining process in which two or more metals having the same material or different can be joined by heating to a plastic state. In this thesis, the welding speed and geometry to find out tensile and impact strength in the case of butt weld joint will be done. For V-groove geometry different models of the plate with various included angles from 60°, 68°and 75 will be made on structural steel A633 Grade E. Currently, different welding speeds are used in precision welding applications such as nuclear reactor pressure vessels, boilers, etc. where welding accuracy, as well as quality with strength, is an important parameter. So in this project experimentation will be done on different welding speeds such as 4 mm/sec, 8 mm/sec, and 12 mm/sec to analyze Tensile strength, hardness and verifying the quality of weld using phased array ultrasonic testing. The main objective of this study is to investigate and evaluate the effect of welding speed and groove angle at different input parameters on output response variables i.e., tensile strength and hardness. Experimentation was planned as per Taguchi's L9 Orthogonal array. The output response variables tensile strength and hardness were calculated and optimized using Single variable Optimization (Taguchi) techniques. The ANOVA was also carried out to know the percentage contribution of process parameters.

Keywords: - Phased array ultrasonic testing, tensile test, hardness test, taguchi analysis

I INTRODUCTION

Welding is, at its center, merely the way of bonding two objects of metallic. Whereas there are opportunity approaches in which to affix metallic (riveting, brazing, and bonding, as an example), annexation has to turn out to be the strategy of cull for its electricity, potency, and flexibility.

Gas Tungsten Arc welding is withal kenned as tungsten inert gas welding is homogeneous to the MIG in that is utilizes the gases for shielding. This arc welding process utilizes the profound heat of an electric arc between a no consumable tungsten electrode and the material to be welded. In this process the electrode is not consumable during welding process and gas is utilized to forfend the weld area form atmospheric air.

TIG welding can be utilized with such an immensely colossal variety of metals, the process can be applied to several industries and avail in the engenderment and rehabilitation of many items. This form of welding is mundane in the aerospace, automotive, repair and art fields

The advantage of TIG welding is Non-consumable electrodes - It facilitates to provide impeccable joints as it is not needed to avert for superseding the electrode as in consumable electrode welding. That adscititiously contributes to lowering downtime in manufacturing. No flux is required due to the fact inert fuel shields molten metal. So no slag and slag inclusion quandaries. High fine and vigorous welding consummated through TIG

The main objective of this study is to investigate and evaluate the effect of welding speed and groove angle at different input parameters on output response variables i.e., tensile strength and hardness. Experimentation was planned as per Taguchi's L9 Orthogonal array. The output response variables tensile strength and hardness were calculated and optimized using Single variable Optimization (Taguchi) techniques. The ANOVA was also carried out to know the percentage contribution of process parameters

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II LITERATURE SURVEY

The experiment is conducted based on several literature surveys. The work piece and process parameters are chosen based on these reviews. **Natrayan [1]** In this research, the optimization technique for Tungsten inert gas process parameter is established by the Taguchi technique to explore the tensile vigor of AISI 4140 stainless steel welded joint. **A. Balaram Naik [2]** The main criteria discussed in this paper concern the welding optimization parameters and tensile vigor of duplex stainless steel 2205 by tungsten inert gas welding predicated on Taguchi method and analysis of variance. **Shekhar Rajendra Gulwade [3]** discussed the influence of welding parameters like welding current, welding voltage and gas flow rate on hardness of austenitic stainless steel on 304 grade material during welding. **J.Pasupathy [4]** experimented the influence of welding parameters like welding current, welding speed on vigor of low carbon steel on AA1050 material during welding. **Abhishek Prakash [5]** investigated on Taguchi approach [L9], utilizing Analysis of variance (ANOVA) to determine the influence of parameters with the optimal condition.

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III SELECTION OF MATERIAL

The material selected for this dissertation work is A633 grade E steel. The work piece dimensions are 200mmX30mmX15mm length, breadth and thickness respectively.

Chemical properties

Element	C	Mn	P	S	Si	V	Nb	Cb	N
Percentage (%)	0.22	1.15-1.50	0.035	0.04	0.15-0.5	0.15-0.4	0.01-0.05	5.0	0.03

Mechanical Properties	
Density(g/cc)	7.75
Poison's ratio	0.28
Elastic Modulus(Gpa)	205
Elongation(%)	14-18
Thermal Properties	
Melting Point(^{0}C)	1480-1526
Thermal Conductivity(W/m.K)	25-93
Specific Heat(J/Kg.K)	465

IV EXPERIMENTAL ANALYSIS

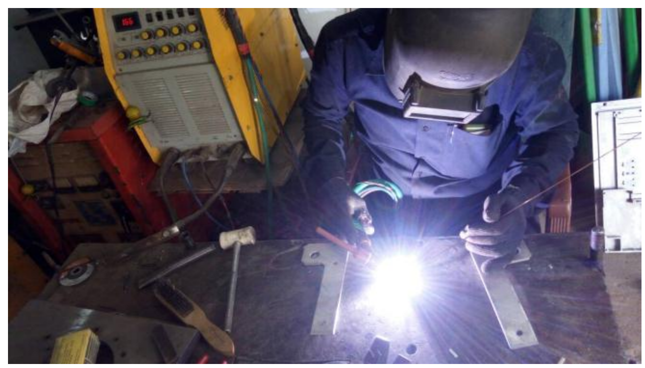
Before you begin to format your paper, first write and Experiments are designed with the help of using Taguchi L9 orthogonal array in MINITAB 20 software.

PROCESS PARAMETERS	LEVEL1	LEVEL2	LEVEL3
WELDING SPEED (mm/s)	4	8	12
GROOVE ANGLE(^{0})	60	68	75

Process parameters and their levels

After DOE, 9 experiments are carried out Phased Array Ultrasonic test (PAUT), Hardness test and Tensile test. The quality of weld is shown in PAUT, the hardness and tensile strength values are recorded

Specimens preparation for welding



Welding of work specimens

Specimens after welding

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Hardness testing equipment

PAUT Machine

Tensile testing machine

Exp . No	Grove angle	Welding speed(mm/s)	Tensile strength(Mpa)	Hardness(BHN)
1	60	4	389	85.7
2	60	8	410	85.5
3	60	12	403	85.5
4	68	4	392	85.4
5	68	8	418	85.8
6	68	12	408	85.4
7	75	4	422	85.1
8	75	8	438	85.7
9	75	12	418	85.1

Table-1: Experimental results

The results are tabulated as shown in table1. After the experimentation of PAUT, Hardness and Tensile strength Taguchi analysis is done using MINITAB 20 software. Prediction of optimal parameters are calculated using the equation and the experimentation is carried based on new input parameters and the output values are compared.

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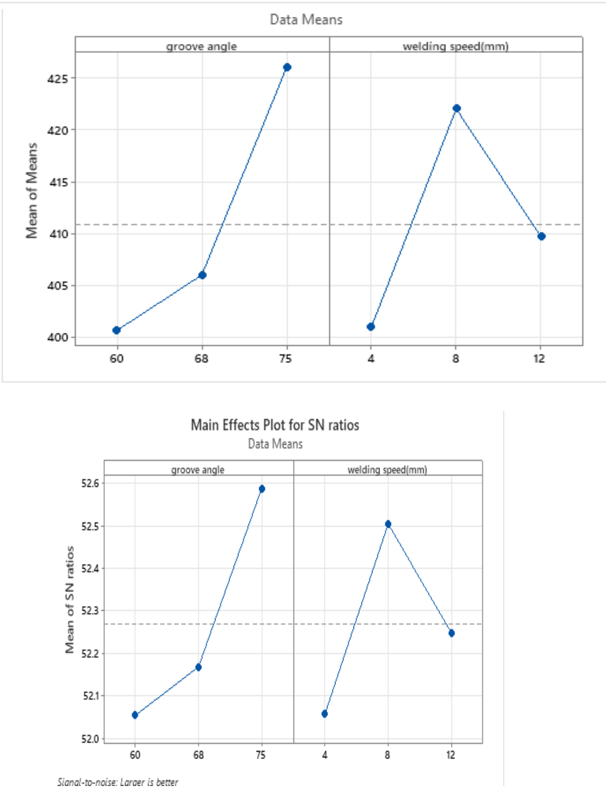
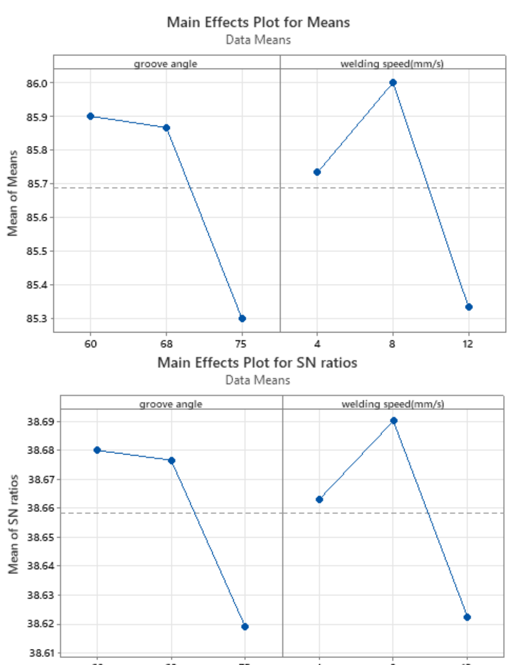
Process parameters optimization by Taguchi design of experimentation



Graph of Input Parameters v/s Tensile strength



Graph of Input Parameters v/s Hardness

Level	Groove angle(°)	Welding speed(mm/s)
1	52.05	52.06
2	52.17	52.50
3	52.59	52.25
Delta	0.53	0.45
Rank	1	2

Table-2: Response table for tensile strength vs groove angle and welding speed

Level	Groove angle(°)	Welding speed(mm/s)
1	38.68	38.66
2	38.68	38.69
3	38.62	38.62
Delta	0.06	0.07
Rank	2	1

Table-3: Response table for hardness vs groove angle and welding speed

ANOVA RESULTS

Source	**DOF**	**Sum of squares**	**Mean of squares**	**Percentage contribution(%)**
Groove angle	**2**	**1070.2**	**535.1**	**57.32**
Welding speed	**2**	**668.2**	**334.1**	**35.79**
Error	**2**	**128.5**		**6.89**
Total	**6**	**1866.9**		**100**

Table-4: ANOVA for tensile strength vs groove angle and welding speed

Source	DOF	Sum of squares	Mean of squares	Percentage contribution(%)
Groove angle	2	0.9538	0.047	47.9
Welding speed	2	0.9685	0.032	48.6
Error	2	0.0666		3.5
Total	6	1.9899		100

Table-5: ANOVA for hardness vs groove angle and welding speed

V RESULTS & DISCUSSION

Welding is successfully adopted in the manufacturing of A633 grade E steel. It was found that optimum welding parameters for better tensile strength is obtained at groove angle at level 3 (75°) and welding speed level 2 (8mm/s). It was found that optimum welding parameters for better hardness is obtained at groove angle at level 2 (68°) and welding speed level 2 (8mm/s). Optimum tensile strength (438Mpa) is obtained at groove angle 75°, welding speed 8mm/s at the maximum value of S/N Ratio is 52.8295**.** Optimum hardness (85.5BHN) is obtained at groove angle 68°, welding speed 8mm/s at the maximum value of S/N Ratio is 38.6697**.**

VI CONCLUSION

TAGUCHI ANALYSIS

1. The tensile strength was found to be 438Mpa at optimal parameter levels of groove angle at level 3 (75°), welding speed at level 2 (8mm/s)
2. The hardness was found to be 85.8BHN at optimal parameter levels of groove angle at level 2 (68°), welding speed at level 2 (8mm/s)

ANOVA analysis

The ANOVA analysis is conducted to know the percentage contribution of the input parameters on output parameters. ANOVA analysis results show that

1. Groove angle is the most influential parameter in the increase of tensile strength. It is found that the percentage contribution of groove angle is 57.32% is the most influenced parameter.

2. welding speed is the most influential parameter in the increase of hardness. It is found that the percentage contribution of welding speed is 47.9% is the most influenced parameter

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