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Impact of the Welding Parameters on the Width of the Welding beat in TIG Carbon Steel Welding

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***Abstract** - Tungsten Inert Gas (TIG) welding is otherwise known as the Gas Tungsten Arc soldering (GTAW) process which when significant levels of weld quality or high precision welding are required, is known to represent an advanced arc welding process. However the impact of the welding factors on this form of welding is important for its welding produced in single-pass welding. In this investigation, the autogenous Tungsten Inert Gas (TIG) welding was performed on a carbon mild steel plate with four parametric welding variables. High and low values of material thickness, welding current, welding speed and filler rod diameter have been measured in order to have an impact on an observable parametric response i.e. welding distance. Geometry of the weld bead has been investigated. An expert statistical software design expert has created a mathematical model, The experimental design is central composite design (CCD) and the sold width is the response measured by the Surface Response Methodology (RSM). It has been shown that the maintenance of a suitable parametric welding factor for a carbon steel plate gives substantial values of welding width.*

***Keywords:** Tungsten Inert Gas , Welding, Expert Design, Central Composite Design, Response surface methodology and A - TIG welding process.*

I. INTRODUCTION

Tungsten inert gas welding also is classified as gas tungsten arc welding (GTAW), using this heat generated by the electrical arc occurring between the non-consumable tungsten electrode and the metal fuse workpiece in the joint area and create the molten weld beat pool. The arc zone is covered in an inert gas shield to shield the weld-beat pool and the non-consumable electrode. The process may be operated automatically without or with a filler, the filler may be inserted by feeding the consumable rod or wire into the formed weld. TIG manufactures exceptionally high-quality welds through a wide variety of materials with thicknesses of up to 8 mm. It is especially well suited for sheet material.

In this Tungsten inert gas welding we discuss the effect of main TIG welding parametric factors like thickness of material , current welding , welding speed and filler rod diameter on the weld surface methodology response such as a width of weld , Using & setting advanced optimization TIG Welding Factors such as material thickness, setting current , setting voltage , electrode diameter & welding speed improve a good weld beat produced. On a base of above observation, in this work the present autogenous (TIG) Conventional welding has been achieved with a multi-sample material to be welded. Further to get an optimum parameter factors has been considered for TIG welding of mild steel plate.

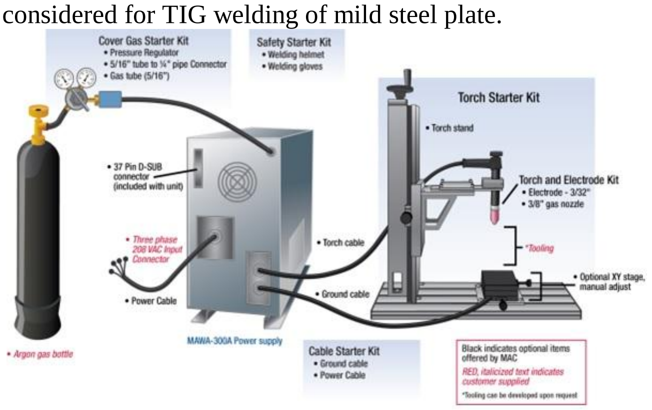

Figure 1Tungsten Inert Gas Welding Process

II. REVIEW CRITERIA

Vikesh et al. The effect of tungsten inert (TIG) welding process activated flux has been studied. In tungsten inert gas (TIG) solding, they focused on the effect of penetration into mild steel. It has no penetration depth relative to other arc welding methods. To avoid this problem, an activating flow powder is used. Taguchi optimisation is used to configure parameters for the welding process by using the mild steel TIG welding method. They observe experimental effects, which increase penetration depth in the soldering zone with increasing solder current. Penetration depth is inverse relationship to the traveling speed [5].

Prakash Mohan. An automatic TIG welding system was developed that regulates the welding speed during in the TIG welding process for the weld quality of aluminum (Al) plates. (Al) plate welding was carried out in two phases [6].

Juang.S.C. et.al The selection has been noted that there are many qualitative examples in the process pool selection, such as front height, back height, front width and backwidth of the weld pool. The method of Taguchi is used to evaluate each process in an ideal soil geometry to determine process parameters. The suggested method is estimated using experimental data. [7].

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Nayee et al. Studied the effect of oxide-based flow on the metallurgical and mechanical properties of welded joints, Welds of 6mm thick, mild steel and stainless steel flux plate, developed with the aid of inert gas tungsten solding systems. ZnO, TiO2 and MnO2 powder were used for its analysis.

In comparison to the traditional TIG welding method, the highest width to depth ratio is under TiO2and ZnO fluxes. TiO2 has the lowest angular deformation of all three streams. [8].

Ipek .N. E.et.al. The effects of a gas metal arc welding process, common in the production of various ferrous and nonferrous metals, have been studied because it improves welding efficiency in most cases. The main focus of this study is the development of an approval to define key TIG variables and optimize process variables using integrated and target programming methods. This paper provides a technique to evaluate variables of a GMA process using a complete factor of regression analysis, experiments and target programming with different objectives. [9].

III. MATERIALS AND METHOD

A. Materials

The material used in this experimental work to investigate Plat butt weld joint . Two different of the carbon steel plates AISI/ASTM 1020 thickness as shown on table below were cut off 400nmm x 100nmm dimensions by the aid of band saw machine . The ends to be soldered were processed in fixed grinding machine, to produces the suitable contact is possible among the carbon steel plates to be combined .

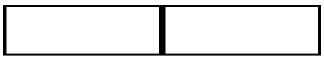
Table 1. Chemical composition of work material AISI/ASTM 1020

Elements	Carbon	Fe	Mn	P	S
Weight %	0.17	99.08	0.3	0.4	0.05

B. Welding geometry

The both samples of carbon steel plates are fused welded by the single type of V-groove butt welds with fixed groove distance between them.

A Geometry of butt weld joint is as follows:



Closed Square

C. Welding process

The TIG welding is utilized the electric arc welding process, which it have a high concentrated arc is produced among tungsten electrode and workpiece. In this type of welding mostly The workpiece has a positive terminal connection and an electrode has a negative terminal connection. This arc generates a heat energy which is further used for fusion soldering to link the metal plate.

D. Experimental

The sample is preparation from carbon steel plates were fixed in the table by Vise with a proper clamping over bolts. Source direct current (DC) per direct polarization negative electrode and positive sample workpiece used to achieve welding. Tungsten electrode of 1.6 mm diameter was used as electrode . Two different values of source current , feed speed, plate thickness and filler rod . the total 16 experiments were performed on table 3 .

Table 2. Welding parameters for autogenous TIG welding of carbon steel

Dimension of Carbon Steel Plate	Length 40mm x Width 10mm x Thickness (2.6 & 1.05mm)
Welding speed	2.77 mm/s and 1.61 mm/s
Arc voltage	6.3 – 7.2 V
Welding current	70 A and 80 A
Gas flow rate	13 l/min
Current type	DC (positive workpiece& negative electrode)
Distance between tip and weld	2.5 mm
Fixed Gap	2.4 mm
Shielding gas	Argon
Arc voltage	20

Table 3 Experimental planning for autogenous TIG welding of mild steel

Exp. No.	Thickness of Plate (mm)	Welding current (A)	Rod Filler Diameter (mm)	Welding speed (mm/s)
1	2.6	80	2.25	2.77
2	1.05	80	2.25	2.77
3	2.6	70	2.25	2.77
4	1.05	70	2.25	2.77
5	2.6	80	1.45	2.77
6	1.05	80	1.45	2.77
7	2.6	70	1.45	2.77
8	1.05	70	1.45	2.77
9	2.6	80	2.25	1.61
10	1.05	80	2.25	1.61
11	2.6	70	2.25	1.61
12	1.05	70	2.25	1.61
13	2.6	80	1.45	1.61
14	1.05	80	1.45	1.61
15	2.6	70	1.45	1.61
16	1.05	70	1.45	1.61

E. Experimental

After perform TIG welding process of carbon steel plate, the welded workpieces were visual inspection of the weld zone. The parameters is recorded as height and width of weld beat, penetration and heat zone width, this parameters checked for each weld sample.

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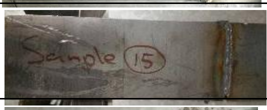
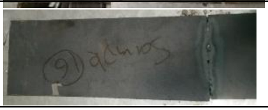
The result of TIG welded workpiece geometry for carbon steel plate performed with different parameters factors input show in Table 4 .

Table 4 Optical Image and Weld bead geometry for autogenous TIG welding of Carbon Steel

Exp. No.	Width of Beat (A)	Welded Joint Images
1	7.0	
2	6.2	
3	7.0	
4	5.0	
5	8.1	
6	6.5	
7	8.3	
8	4.2	
9	7.0	
10	6.0	
11	6.0	
12	4.0	
13	6.0	
14	4.0	
15	7.0	
16	4.5	

F. Analysis Method

The Central Composite Design (CCD) for Welded workpiece performed by single pass weld beat autogenous TIG welding on carbon steel plate sheet type.

The experimental design for this investigation is CCD and the response measured by Response Surface Methodology (RSM) are the width of weld. Since the response of its width is the function of input parameter as shown in Equation To optimize and effective the process parameter ,analyze the welded workpiece of the four diverse autonomous control parameter factors; material thickness, welding current, filler rod diameter and speed show in table 5 , on each output listed parameters .

The CCD was a 2-level four-factor experimental design in this study with a total of 16 experiments as shown in table 3. The four factors were based on two levels (low and high).

Table 5 Diverse autonomous control parametric factors of TIG welding of mild steel

Factor	Name	Units	Type	Minimum	Maximum	Mean	**Std. Dev.**
A	Thickness	mm	Numeric	1.05	2.60	1.83	0.8004
B	Current	A	Numeric	70.00	80.00	75.00	5.16
C	Rod Filler Dia.	mm	Numeric	1.45	2.25	1.85	0.4131
D	Speed	mm/sec	Numeric	1.61	2.77	2.19	0.5990

Response measured by RSM of TIG welding of Carbon steel plates.

Table 6 RSM of TIG welding of mild steel

Response	R1
Name	Width of Weld
Units	mm
Observations	16
Analysis	Polynomial
Min.	4
Max.	8.3
Mean	6.05
Std. Dev.	1.38
Ratio	2.08
Transform	Square Root
Model	Quadratic

Study the effect of input Factors Thickness , Current , Rod Diameter & Welding speed on Response No1 " Width of Weld by ANOVA for Quadratic model (Aliased) on Table 7.

Table 7 Response 1: Width of Weld

Source	**Sum of Squares**	**df**	**Mean Square**	**F-value**	**p-value**	
Model	25.95	10	2.60	5.21	0.0412	significant
A-Thickness	16.00	1	16.00	32.13	0.0024	

B-Current	1.44	1	1.44	2.89	0.1498	
C-Rod Diameter	0.0100	1	0.0100	0.0201	0.8928	
D-Speed	3.80	1	3.80	7.64	0.0397	
AB	1.69	1	1.69	3.39	0.1248	
AC	1.21	1	1.21	2.43	0.1798	
AD	0.0625	1	0.0625	0.1255	0.7376	
BC	0.8100	1	0.8100	1.63	0.2582	
BD	0.2025	1	0.2025	0.4066	0.5517	
CD	0.7225	1	0.7225	1.45	0.2823	
A^2	0.0000	0				
B^2	0.0000	0				
C^2	0.0000	0				
D^2	0.0000	0				
Residual	2.49	5	0.4980			
Cor Total	28.44	15				

The 5.21 F-value model indicates that the model is significant.. There are only a 4.12% chance that an F-value this large could occur due to noise.

P-values less than 0.0500 indicate model terms are significant. In this case study A, D are significant model terms.

Final Equation in Terms of Actual Factors

Width of Weld=

+1.82105

+8.91727 Thickness

-0.080017 Current

-4.87512 Rod Diameter

-0.628215 Speed

-0.083871 Thickness * Current

-0.887097 Thickness * Rod Diameter

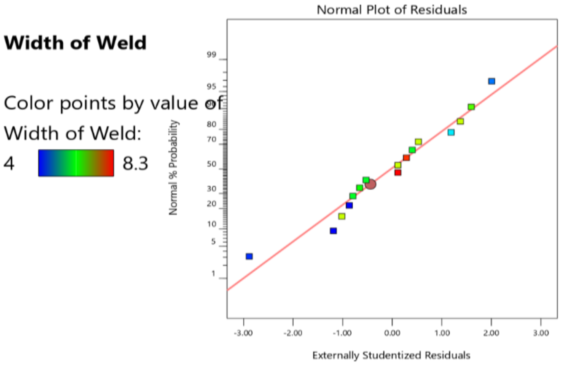
+0.139043 Thickness * Speed

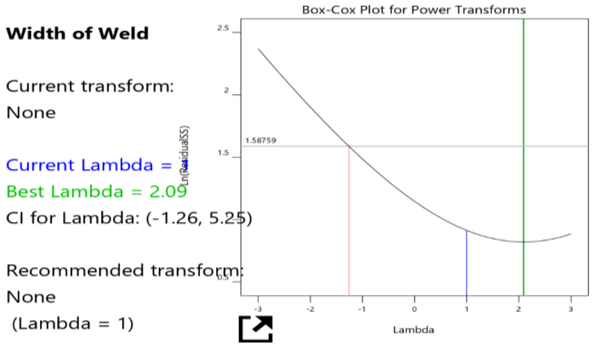
+0.112500 Current * Rod Diameter

+0.038793 Current * Speed

-0.915948 Rod Diameter * Speed

The above equation in terms of real factors can be used to make predictions about the response for given levels of each factor. Here, the levels should be specified in the original units for each factor. Diagnostic Graphs between each factors with response no.1 " Width of Weld" :





Report of relation between each input factors with response no.1 " Width of Weld"

N	Actual Value	Predicted Value	Residual	Leverage	Inter. Stude. Residuals	Exter. Stude. Residuals	Cook's Distance	Influence on Fitted Value DFFITS	Standard Order
1	7.00	7.40	-0.4000	0.688	-1.014	-1.018	0.206	-1.509	10
2	6.20	6.47	-0.2750	0.688	-0.697	-0.656	0.097	-0.973	5
3	7.00	6.78	0.2250	0.688	0.570	0.528	0.065	0.783	13
4	5.00	4.55	0.4500	0.688	1.141	1.186	0.260	1.759	14
5	8.10	7.98	0.1250	0.688	0.317	0.286	0.020	0.425	4
6	6.50	5.95	0.5500	0.688	1.394	1.595	0.389	2.366	7
7	8.30	8.25	0.0500	0.688	0.127	0.114	0.003	0.168	9
8	4.20	4.93	-0.7250	0.688	-1.838	-2.886	0.676	-4.280(1)	3
9	7.00	6.50	0.5000	0.688	1.267	1.376	0.321	2.041	15
10	6.00	5.83	0.1750	0.688	0.444	0.405	0.039	0.600	2
11	6.00	6.33	-0.3250	0.687	-0.824	-0.793	0.136	-1.176	12
12	4.00	4.35	-0.3500	0.688	-0.887	-0.865	0.157	-1.282	8
13	6.00	6.23	-0.2250	0.688	-0.570	-0.528	0.065	-0.783	6
14	4.00	4.45	-0.4500	0.688	-1.141	-1.186	0.260	-1.759	1
15	7.00	6.95	0.0500	0.688	0.127	0.114	0.003	0.168	11
16	4.50	3.88	0.6250	0.688	1.584	2.008	0.502	2.978(1)	16

Current transformer : Sqr (Hight of Weld)

Best lambda	95% CI	95% CI High
2.09	-1.26	5.25

Model Graphs interaction between two factors Current & Thickness with and Response no.1 " Width of Weld":

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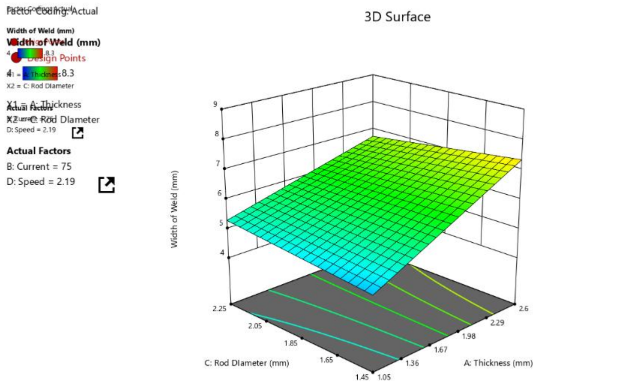
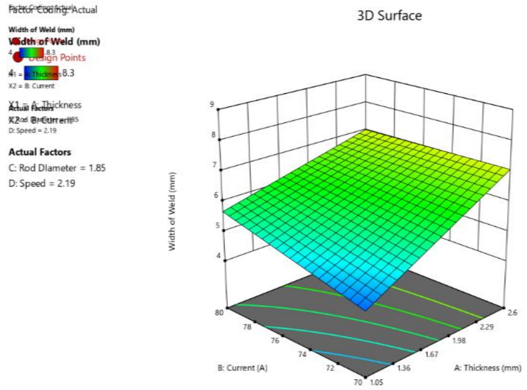
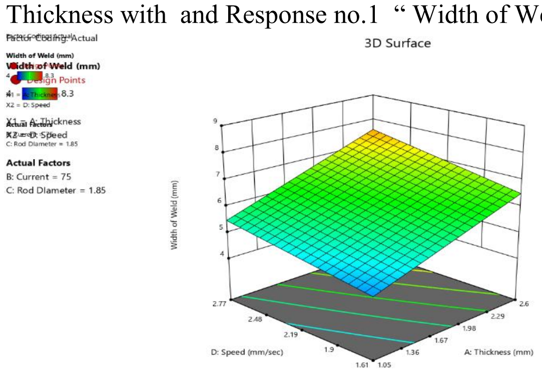


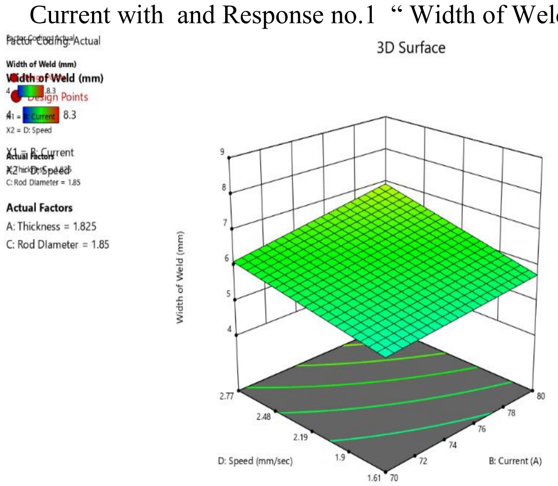
Model Graphs interaction between two Factors Rod filler Diameter & Thickness with and Response no.1 " Width of Weld":



Model Graphs interaction between two Factors Speed & Thickness with and Response no.1 " Width of Weld":



Model Graphs interaction between two Factors Speed & Current with and Response no.1 " Width of Weld":



The most effect on Width of Weld "Response No.1 " is combination of material Thickness , Welding current & Welding speed , the Width of Weld is directional relation with material thickness , Welding current & Welding Speed with no effect on Rod diameter factors .

IV. RESULT AND DISCUSSION

As a result of the present experimental investigation can be summarized a main points as following:

1) As results of the TIG welding process show that, the maximum Width of weld was obtained with factors "parametric" combination of maximum material thickness , current and welding speed.
2) Comparing the effect parametric factors on the parametric responses of TIG welding, Thickness of material is most effect then the welding current then the welding speed with less effect on rod filler diameter .
3) From the plotted & 3d graphs , it can be inferred that welding beat width and depth continuously increases with increase in welding factors as current and speed.

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