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PARAMETRIC OPTIMIZATION OF TIG WELDING USING TAGUCHI METHOD

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ABSTRACT

The present study pertains to the improvement of tensile strength of mild steel weld specimen made of Tungsten inert gas (TIG) welding. L9 Orthogonal array (OA) of TAGUCHI Method has been used to conduct the experiments using several levels of current, gas flow rate and filler rod diameter. Statistical techniques analysis of variance (ANOVA), signal-to –noise(S/N) ratio and graphical main effect plots have been used to study the effects of welding parameters on tensile strength of weld specimen. Optimum parametric condition obtained by TAGUCHI method.

Keywords: *Tungsten inert Gas welding , TAGUCHI Method, Tensile strength, analysis of variance , signal – to –noise ratio , Optimum parametric condition*.

INTRODUCTION

TIG Welding is a manual welding process that requires the welder to use two hands to weld. What separates TIG welding from most other welding processes is the way the arc is created and how the filler metal is added! When TIG Welding one hand is used for holding the TIG torch that produces the arc and the other hand is to add the filler metal to the weld joint. Because two hands are required to weld; TIG welding is the most difficult of the processes to learn, but at the same time is the most versatile when it comes to different metals. This process is slow but when done right it produces the highest quality weld! TIG welding is mostly used for critical weld joints, welding metals other than common steel, and where precise, small welds are needed.

Tungsten inert gas (TIG) welding is an arc welding process that produces coalescence of metals by heating them with an arc between a non-consumable electrode and the base metal (Kumar and Sundarrajan, 2009). TIG welding offers several advantages i.e. joining of dissimilar or similar metals, low heat affected zone, absence of slag etc. In TIG welding operation, weld quality mainly depends on features of bead geometry, mechanical-metallurgical characteristics of the weld and various aspects of weld chemistry. These features are greatly influenced by the welding parameters such includes current, voltage, gas flow rate, electrode stick-out, edge preparation, position of welding, weld speed (Ghosh et al 2013) etc. Selection of filler rod diameter also has significant effect on weld quality. Selection of optimum parametric setting is essential for obtaining desired weld quality.

LITERATURE REVIEW

Many investigators have suggested various methods to explain the effect of process parameter on Tig welding process in material properties.

2.1 journals reviews

Sanjeevkumaret. alattempted to explore the possibility for welding of higher thickness Plates by TIG welding. Mild steel Plates (5-6mm thickness) were welded by Pulsed Tungsten Inert Gas Welding process with welding current in the range 130-160 A and gas flow rate 7 -15 l/min. Shear strength of weld metal (390MPa) was found less than parent metal(408 MPa). From the analysis of photomicrograph of welded specimen it has been found that, weld deposits are form co-axial dendrite micro-structure towards the fusion line and tensile fracture occur near to fusion line of weld deposit.

Indira Rani et. alinvestigated the mechanical properties of the elements of mild steel during the GTAW /TIG welding with non-pulsed and pulsed current at different frequencies. Welding was performed with current 140-160A, , with variable filler rod diameter of 1.6-2.4 mm. From the experimental results it was concluded that the tensile strength and YS of the elements is closer to base metal. Failure location of elements occurred at HAZ and from this we said that elements have better weld joint strength.

Ahmed Khalid Hussainet. alinvestigated the effect of welding speed on tensile strength of the welded joint by TIG welding process of mild steel plate 5 mm thickness. The strength of the welded joint was tested by a universal tensile testing machine. Welding was done on specimens of single v butt joint. From the experimental results it was revealed that strength of the weld zone is less than base metal and tensile strength increases with reduction of welding speed.

Tseng et. alinvestigated the effect of activated TIG process on weld morphology, angular distortion, delta ferrite content and hardness of 316 L stainless steel by using different flux like TiO_2, MnO_2, MoO_3, SiO_2 and Al_2O_3. To join 6 mm thick plate author uses welding current 200 Amp, welding speed 150 mm/min and gas flow rate 10 l/min. From the experimental results it was found that the use of SiO_2 flux improve the joint penetration, but Al_2O_3 flux deteriorate the weld depth and bead width compared with conventional TIG Process

Naranget. al performed TIG welding of structural steel plates of different thickness with welding current in the range of 140-160 A, and welding speed of 15-45 mm/sec. To predict the weldment macrostructure zones, weld bead reinforcement, penetration and shape profile characteristics along with the shape of the heat affected zone (HAZ), fuzzy logic based simulation of TIG welding process has been done.

Karunakaranet. alperformed TIG welding of mild steel and compare the weld bead profiles for constant current and pulsed current setting. Effect of welding current on tensile strength, hardness profiles, microstructure and residual stress distribution of welding zone of steel samples were reported. For the experimentation welding current of 100-180 A, welding speed 118.44 mm/min, pulse frequency 6 Hz have been considered. Lower magnitude of residual stress was found in pulsed current compared to constant current welding. Tensile and hardness properties of the joints enhanced due to formation of finer grains and breaking of dendrites for the use of pulsed current.

TAGUCHI METHOD

The Taguchi method is a powerful tool for the design of high quality systems. It provides a simple, efficient and systematic approach to optimize designs for performance, quality and cost. The methodology is valuable when process parameters are qualitative and discrete. The parameter design based on the Taguchi method can optimize the quality characteristics through the settings of process parameters and reduce the sensitivity of the system performance to the sources of variation. In recent years, many applications of the Taguchi method have been available in a world wide range of industries. A weighting method is applied to the Taguchi method to consider the tensile strength and hardness.

It employees a set of orthogonal experimental design arise to investigate the influence of process parameters of the friction stir welding. In design concept, the product must be produced at optimal levels with minimum variation in its functional characteristics. Taguchi belied that the best opportunity to eliminate variation is during design of product and its manufacturing process. Taguchi proposed that the engineering optimization of a process or product should be carried out in a three-step approach via :

1. **System design:** It determines the general specifications and physical envelope of the product. It helps to identify working levels of the design parameters. In the system design, the engineer applies scientific and engineering knowledge to produce a basic functional prototype design. This prototype design includes the product design stage and the process design stage. In the product design stage, the selection of materials, components, tentative product parameter values, etc., are involved. As to the process design stage, the analysis of processing sequences, the selections of production equipment, tentative process parameter values etc., are involved. Since the system design is an initial functional design, it may be far from optimum in terms of quality and cost.

2. **Parameter design:** It determines the levels of product and manufacturing process parameters that provide the best performance of the product or process under study. The objective of the parameter design is to optimize the settings of the process parameter values to improve quality characteristics and to identify the product parameter values under the optimal process parameter values. In addition, it is intended that the optimal process parameters obtained from the parameter design are insensitive to the variation of environmental conditions and other noise factors.

3. **Tolerance design**: It selects manufacturing tolerance value for each of these parameters. It is a step to fine-tune the results of parameter design. The tolerance design is used to determine and analyses tolerances around the optimal settings recommended by the parameter design. The

tolerance design is required if the reduced variation obtained by the parameter design does not meet the required product performance. It involves tightening tolerances on the product parameters or process parameters whose variations result in a large negative influence on the required product performance. Typically, tightening tolerances means purchasing better grade materials, components, or machinery thus increasing the cost.

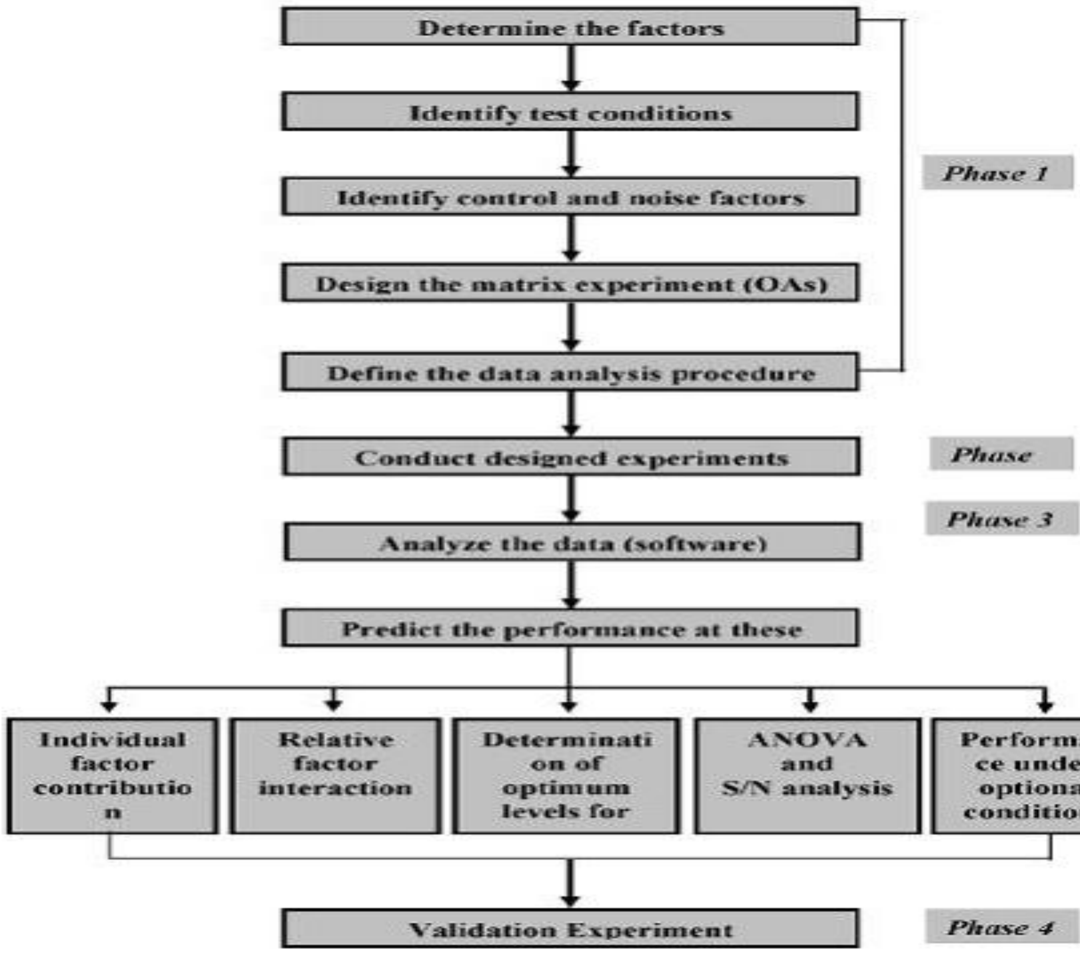


Table 3.1 Controllable factors

S.No.	Factor	Level 1	Level 2	Level 3
1	A: current	120	140	160
2	B:gas flow rate	08	10	12
3	C:filler rod diameter	1.6	2.0	2.4

EXPERIMENTAL DETAILS

The plan has been made and work-piece materials (i.e. mild steel) have been cut into desired dimensions. The setup has been made ready and prepared for doing TIG welding. Now butt joints are made under varied conditions of welding as given L9 orthogonal array of Taguchi method. The selected process parameters and its levels are given in Table. Photographic view of the experimental set up is shown in Fig. for obtain better weld joint the filling operation is done on work pieces before going to welding operation.

Fig 4.1 filling operation

4.1 selected process parameters:

Current

Gas flowrate

Gas flowrate

Filler rod diameters

Fig 4.2 process parameters

2 Experimental set up:

Fig 4.3 Experimental set up

S. No	A	B	C
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

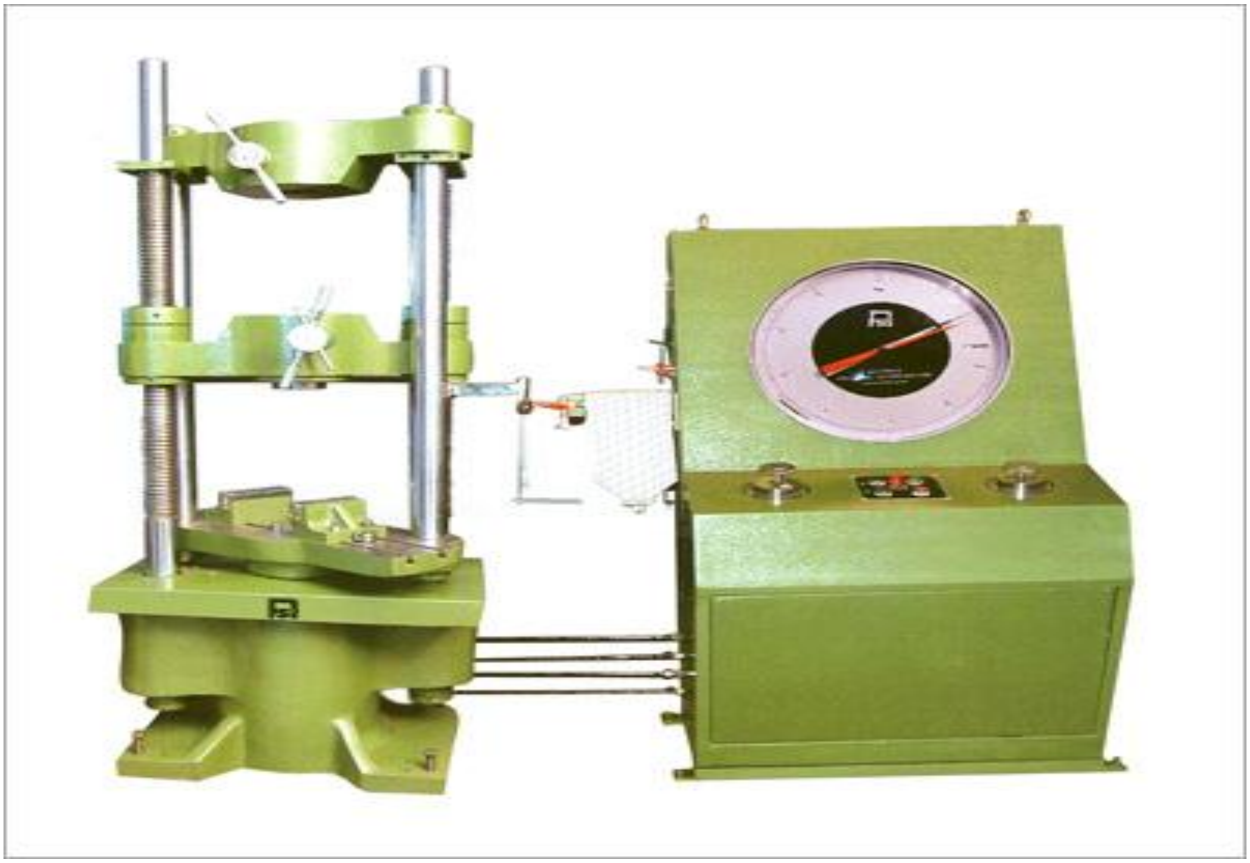


Fig 4.4 Universal Testing Machine

Fig 4.5 Tensile Specimen

RESULT AND DISCUSSION

Taguchi provides many standard orthogonal arrays and corresponding linear graphs for this purpose. In our project we are considering three factors i.e., process parameters of TIG welding are for the three factors and three levels Taguchi proposed some standard array. Hence an $L_9OA(3^2)$ was selected for this study. This array specifies nine experimental runs and has three columns. The layout of this L_9 orthogonal arrays.

5.2 Observation:

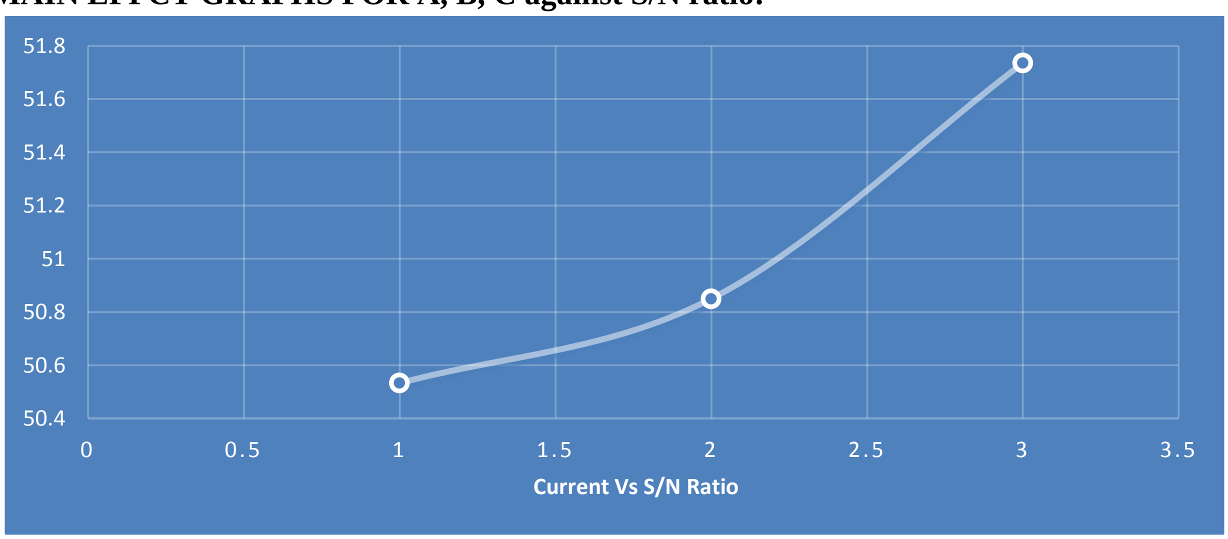
The tensile strength of welded joints are shown in the blow table 5.1

Table 5.1 L-9 orthogonal array Table:

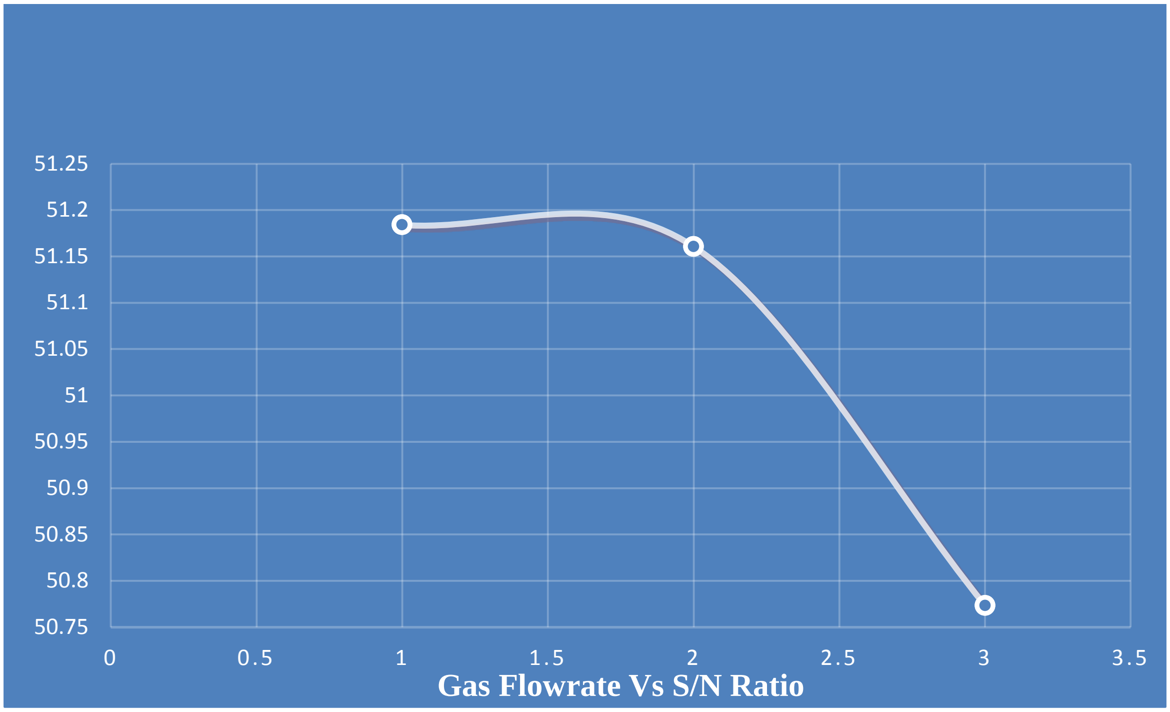
S. No	current (A) (A) Amps	Gas flow rate (B) Lit/min	Filler rod dia (C) mm	Tensile Strength MPa			Average	S/N ratio dB
				Sp 1	Sp 2			
1	120	08	1.6	368.806	359.817		364.3115	51.2320
2	120	10	2.0	306.576	286.713		296.664	49.4309
3	120	12	2.4	355.676	346.598		351.137	50.9633
4	140	08	2.0	323.539	335.598		329.568	50.3574
5	140	10	2.4	387.302	392.426		389.864	51.8177
6	140	12	1.6	327.558	332.792		330.175	50.3763
7	160	08	2.4	407.488	410.297		408.892	52.2329
8	160	10	1.6	393.245	399.492		396.368	51.9654
9	160	12	2.0	352.335	357.538		354.936	51.0072

Now. The Expected optimum condition from the Array without interactions is:**A3 B1 C3**

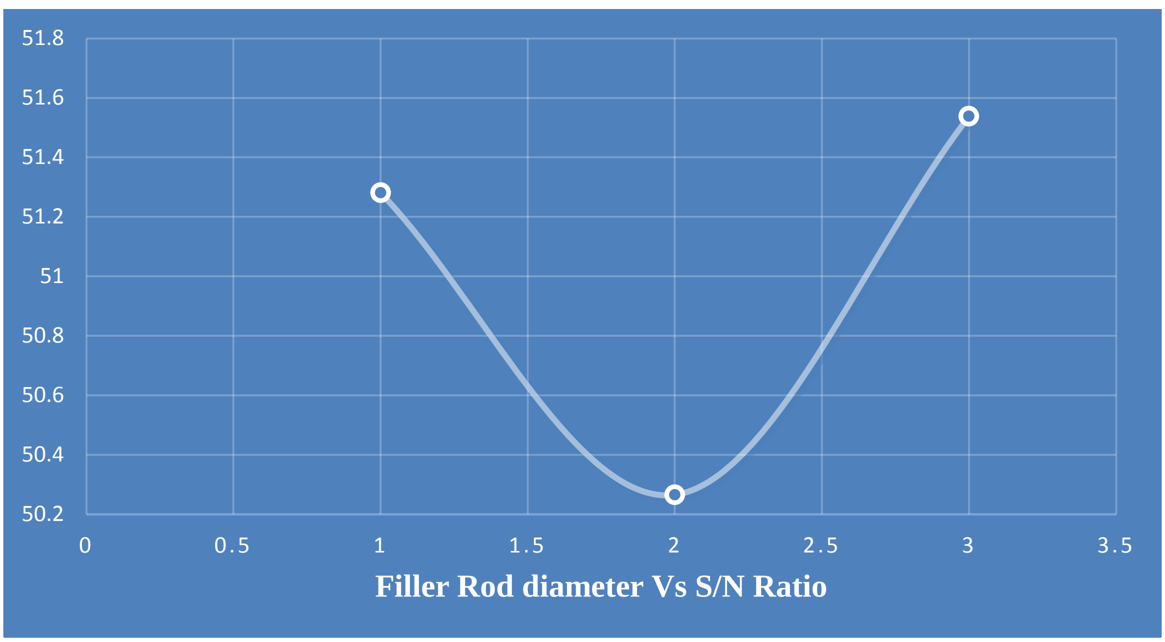
MAIN EFFCT GRAPHS FOR A, B, C against S/N ratio:



Graph 5.1 current Vs S/N ratios



Graph 5.2 Gas flow rate Vs S/N ratios



Graph 5.3 Filler rod diameter Vs S/N ratios

ANOVA TABLE:

Table 5.2 Anova table

Factor	DOF (f)	Sum Of Squares (SS)	Variance (V)	Percentage P(%)
1.Current(A)	2	2.314	1.157	36.04
2.FlowRate(B)	2	1.286	0.643	20.04
3.Filler Rod diameter(C)	2	2.822	1.411	43.92

TABLE5.3 optimum welding condition based on results of S/N ratio:**A3 B1 C3**

Factors	Level description	Level
1.Current	160	3
2.Gas Flow rate	08	1
3.Filler Rod Diameter	2.4	3

CONCLUSION

Tensile strength of mild steel has been evaluated under different processing conditions using 3^3 Full factorial Experimental data applying Taguchi methodology. Primarily, L-9 array is taken into consideration and put to S/N analysis, where the quality control type is Bigger is the Best, because we need Tensile strength to be Maximum and then put to ANOVA, the optimum condition is found to be A3 B1 C3. From the Main effect graphs drawn, Factor C i.e.Filler Rod Diameter is found to be more Dominant parameter for Tensile strength followed by Current and Gas Flowrate.. The current L-9 array is now put to ANOVA and hence it is found to be negligible without altering the Optimum condition as A3 B1 C3 (AC)1. Thus, best optimum conditions of TIG welding are found out to increase its robustness.

A Maximum Tensile strength is exhibited by TIG Welding joints with Optimal Parameters :

Current(A) : 160 Amps
Gas Flow rate (B) : 08 Lit/min and
Filler Rod Diameter (C) : 2.4mm

It shows a reasonable agreement with the optimum condition and its value with the Experimental data Input taken.

- With increase in current tensile strength of weld joint increases.
- For both side welding tensile strength is found almost equivalent to the strength of base material.

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