

# Experimental Analysis to Improve Dissimilar Weldments Quality and Safety Aspects by Using Modified Flux Core Arc Welding Process

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**ABSTRACT:** In this competitive world, the customers perceive the most reliable high quality with low cost product. Gas metal arc welding famously abbreviated MIG is one of the most important metals joining process in manufacturing industries. The selection of improper FCAW process parameter increases the power consumption, material consumption, man power and cost of the product decreasing the weld quality. This project work is part of program for the development of EN8&OHNS steels has to be increase mechanical properties and minimization of metallurgical defects to increasing weldment. The quality of weld in FCAW mainly influenced by independent variables such as welding current, voltage & Gas pressure. The planned experiments are conducted in the MIG welding machine. The toughness value of the MIG welded dissimilar steel was comparatively higher value (180 AMPS VOLT-22 GAS PRESSURE 6 Kg/cm<sup>2</sup>) than other value. It also induces high tensile strength. Finally I concluded that in this project investigation the 180 AMPS Volt-22 Gas Pressure-6Kg/cm<sup>2</sup> is the best parameter for Dissimilar-10 MM thickness plate for obtains the good weldment state. According to the Taguchis design and optimized parameter is value for Impact strength the 10 mm plate of dissimilar carbon grade steel is 160 AMPS Volt-22 Gas Pressure-6Kg/cm<sup>2</sup>.

**KEYWORDS:** FCAW-flux core arc welding, DCEP-Direct Current electrode positive MIG-Metal Inert Gas

## I. INTRODUCTION

Flux Core Arc Welding (FCAW) uses a tubular wire that is filled with a flux. The arc is initiated between the continuous wire electrode and the work piece. The flux, which is contained within the core of the tubular electrode, melts during welding and shields the weld pool from the atmosphere. Direct current, electrode positive (DCEP) is commonly employed as in the FCAW process. There are two basic process variants; self-shielded FCAW (without shielding gas) and gas shielded FCAW (with shielding gas). The difference in the two is due to different fluxing agents in the consumables, which provide different benefits to the user. Usually, self-shielded FCAW is used in outdoor conditions where wind would blow away a shielding gas. The fluxing agents in self-shielded FCAW are designed to not only deoxidize the weld pool but also to allow for shielding of the weld pool and metal droplets from the atmosphere. The flux in gas-shielded FCAW provides for deoxidation of the weld pool and, to a smaller degree than in self-shielded FCAW, provides secondary shielding from the atmosphere. The flux is designed to support the weld pool for out-of position welds. This variation of the process is used for increasing productivity of out-of-position welds and for deeper penetration.

### 1.1 FLUX CORE WELDING PROCESS

Flux core welding or tubular electrode welding has evolved from the MIG welding process to improve arc action, metal transfer, weld metal properties, and weld appearance. It is an arc welding process in which the heat for welding is provided by an arc between a continuously fed tubular electrode wire and the work piece. Shielding is obtained by a flux contained within the tubular electrode wire or by the flux and an externally supplied shielding gas. A diagram of the process is shown in figure 1.1

The flux-cored welding wire, or electrode, is a hollow tube filled with a mixture of deoxidizers, fluxing agents, metal powders, and Ferro-alloys. The closure seam, which appears as a fine line, is the only visible difference between flux-cored wires and solid cold-drawn wire. Flux-cored electrode welding can be done in two ways: carbon dioxide gas can be used with the flux to provide additional shielding, or the flux core alone can provide all the shielding gas and slugging materials. The carbon dioxide gas shield produces a deeply penetrating arc and usually provides better weld than is possible without an external gas shield. Although flux-cored arc welding may be applied semi automatically, by machine, or automatically, the process is usually applied semi automatically.

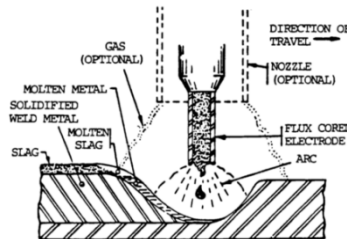


Fig 1.1 Flux Core Welding Process

### 1.2 SHIELDING GASES

The primary purpose of the shielding gas is to protect the arc and weld puddle from contaminating effects of the atmosphere. The nitrogen and oxygen of the atmosphere, if allowed to come in contact with the molten weld metal, cause porosity and brittleness. In flux-cored arc welding, shielding is accomplished by the decomposition of the electrode core or by a combination of this and surrounding the arc with a shielding gas supplied from an external source. A shielding gas displaces air in the arc area. Welding is accomplished under a blanket of shielding gas. Inert and active gases may both be used for flux-cored arc welding. Active gases such as carbon dioxide, argon-oxygen mixture, and argon-carbon dioxide mixtures are used for almost all applications. Carbon dioxide is the most common. The choice of the proper shielding gas for a specific application is based on the type of metal to be welded, arc characteristics and metal transfer, availability, cost of the gas, mechanical property requirements, and penetration and weld bead shape.

### 1.3 ELECTRODES

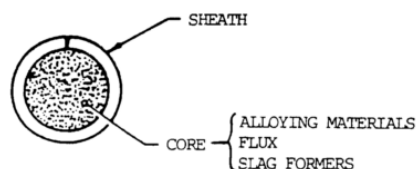


Fig 1.2 Electrodes

The electrodes used for flux-cored arc welding provide the filler metal to the weld puddle and shielding for the arc. Shielding is required for some electrode types. The purpose of the shielding gas is to provide protection from the atmosphere to the arc and molten weld puddle. The chemical composition of the electrode wire and flux core, in combination with the shielding gas, will determine the weld metal composition and mechanical properties of the weld.

The electrodes for flux-cored arc welding consist of a metal shield surrounding a core of fluxing and/or alloying compounds as shown in figure .The cores of carbon steel and low alloy electrodes contain primarily fluxing compounds. Some of the low alloy steel electrode cores contain high amounts of alloying compounds with a low flux content. Most low alloy steel electrodes require gas shielding. The sheath comprises approximately 75 to 90 percent of the weight of the electrode. Self-shielded electrodes contain more fluxing compounds than gas shielded electrodes. The compounds contained in the electrode perform basically the same functions as the coating of a covered electrode used in shielded metal arc welding.

#### *1.4 WELDING MATERIALS*

The GMAW process can be operated in semi-automatic and automatic modes. All commercially important metals, such as carbon steel, high-strength low-alloy steel, stainless steel, and aluminum, copper, and nickel alloys can be welded in all positions by this process if appropriate shielding gases, electrodes, and welding parameters are chosen.

## **II. SCOPE OF THE PROJECT**

The main objective of the project is during welding process we have to get the minimum changes in the physical properties and no metallurgical defect is present. Defect free welding process should be made. To achieve a good weldment we will be working with many samples and quality checks with destructive and non-destructive testing in this experimental work.

## **III. WELDING PROBLEM ON CARBON STEEL**

### *3.1 PROBLEM IDENTIFICATION*

In many cases the welder needs only to know the techniques of actual welding and does not need to be concerned about the type or grade of steel being welded. This is because a large amount of steel used in fabricating a metal structure is low Carbon or plain carbon steel (also called mild steel). When welding these steels with any of the common arc welding processes like Stick Mig or Tig there are generally few precautions necessary to prevent changing the properties of the steel.

Steels that have higher amounts of Carbon or other alloys added may require special procedures such as preheating and slow cooling, to prevent cracking or changing the strength characteristics of the steel. The welder may be involved in following a specific welding procedure to ensure weld metal and base metal has the desired strength characteristics.

### *3.2 THE EFFECT OF WELDING ON CARBON STEEL*

Steel is an alloy, or metallic mixture, containing primarily iron. A variety of other metals, such as carbon, are used to promote certain properties in the alloy. Carbon has a strengthening effect when added to iron.

## **IV. EXPERIMENTAL DESIGN**

### *4.1 TAGUCHI INTRODUCTION*

Basically, experimental design methods were developed original fisher. However experimental design methods are too complex and not easy to use. Furthermore, a large number of experiments have to be carried out when the number of the process parameters increases, to solve this problem, the Taguchi method uses a special design of orthogonal arrays to study the entire parameter space with a small number of experiments only. The experimental results are then transformed into a signal- to - noise (S/N) ratio to measure the quality characteristics deviating from the desired values Usually, there are three categories of quality characteristics in the analysis of the S/N ratio, i.e., the-lower-better, the-higher-better, and the-nominal-better. The S/N ratio for each level of process parameter is compared based on the S/N analysis. Regardless of the category of the quality characteristic, a greater S/N ratio corresponds to better quality characteristics. Therefore, the optimal level of the process parameters is the level with the greatest S/N ratio Furthermore, a statistically significant with the S/N and ANOVA analyses, the optimal combination of the process parameters can be predicted. Finally, a confirmation experiment is conducted to verify the optimal process parameters obtained from the parameter design.

There are 3 Signal-to-Noise ratios of common interest for optimization of Static Problems. The formulae for signal to noise ratio are designed so that an experimenter can always select the largest factor level setting to optimize the quality characteristic of an experiment. Therefore a method of calculating the Signal-To-Noise ratio we had gone for quality characteristic.

**4.2 DESIGN OF EXPERIMENT**

Process parameters and their levels

Levels	Process parameters		
	AMPS	VOLT	GAS PR
1	140	18	4
2	160	20	5
3	180	22	6

Table 4.1 Process parameters and their levels

**4.3 DESIGN OF ORTHOGONAL ARRAY**

First Taguchi Orthogonal array is designed in minitab-16 to calculate S/N ratio and means which steps is given below. Create Taguchi Design is selected as shown in figure. Then a window of Taguchi design is opened. To start Minitab, click shortcut of Minitab on Desktop of computer. A window is opened in computer as shown in Figure 4.1

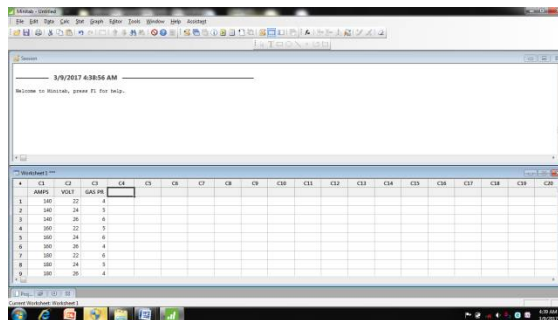


Figure 4.1 Create Taguchi Design

**4.4 AN ORTHOGONAL ARRAY L9 FORMATION (INTERACTION)**

	AMPS	VOLT	GAS PR Lt/min
1	140	18	4
2	140	20	5
3	140	22	6
4	160	18	5
5	160	20	6
6	160	22	4
7	180	18	6
8	180	20	5
9	180	22	4

Table 4.2 Orthogonal Array L9 Formation

**V. EXPERIMENTAL RESULT**

**5.1 INTRODUCTION OF HARDNESS**

There are three types of tests used with accuracy by the metals industry; they are the Brinell hardness test, the Rockwell hardness test, and the Vickers hardness test. Since the definitions of metallurgic ultimate strength and hardness are rather similar, it can generally be assumed that a strong metal is also a hard metal. The way the three of these hardness tests measure a metal's hardness is to determine the metal's resistance to the penetration of a non-deformable ball or cone. The tests determine the depth which such a ball or cone will sink into the metal, under a given load, within a specific period of time. The followings are the most common hardness test methods used in today's technology.

**5.2 ROCKWELL HARDNESS TEST**

1. Rockwell Hardness systems use a direct readout machine determining the hardness number based upon the depth of penetration of either a diamond point or a steel ball. Deep penetration indicated a material having a low Rockwell Hardness number.

2. However, a low penetration indicates a material having a high Rockwell Hardness number. The Rockwell Hardness number is based upon the difference in the depth to which a penetrator is driven by a definite light or "minor" load and a definite heavy or "Major" load.

3. The ball penetrators are chucks that are made to hold 1/16" or 1/8" diameter hardened steel balls. Also available are 1/4" and 1/2" ball penetrators for the testing of softer materials.

4. There are two types of anvils that are used on the Rockwell hardness testers. The flat faceplate models are used for flat specimens. The "V" type anvils hold round specimens firmly.

5. Test blocks or calibration blocks are flat steel or brass blocks, which have been tested and marked with the scale and Rockwell number. They should be used to check the accuracy and calibration of the tester frequently.

Using the "B" Scale;

- a. Use a 1/16 indenter
- b. Major load: 100 Kg, Minor load: 10 Kg
- c. Use for Case hardened steel titanium, tool steel.
- d. Do not use on hardened steel.

SAMPLE S	S1	S2	S3	S4	S5	S6	S7	S8	S9
EN8	98	98	92	93	97	97	98	102	100
OHNS	92	94	91	95	94	94	87	90	94

Table 5.1 Hardness Value-HRB Value

The dimensions of a standard specimen for ASTM D256 are 4 x 12.7 x 3.2 mm (2.5" x 0.5" x 1/8"). The most common specimen thickness is 3.2 mm (0.125"), but the width can vary between 3.0 and 12.7 mm (0.118" and 0.500").

**5.3 IMPACT STRENGTH**

In our Project Impact Strength determined through impact testing machine by charpy method. Specification of the machine and Size of the specimen

Materials	TEST PLATE	Average In Joules
OHNS & EN8	S1	25
	S2	19
	S3	20
	S4	54

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Energy Range =

	S5	20	0 – 300 J
	S6	23	
	S7	26	
	S8	24	
	S9	21	

Table 5.2. Impact strength

Least Count (1 Division) = 2J  
Specimen size = 10 X 10 X 55 mm  
Notch = V NOTCH  
Notch Depth = 2mm

T.No	Designation	AMPS	VOLT	Gas Pr Kg/cm2	Impact	SNRA1
1	A <sub>1</sub> B <sub>1</sub> C <sub>1</sub>	140	22	4	25	27.9588
2	A <sub>1</sub> B <sub>2</sub> C <sub>2</sub>	140	24	5	19	25.5751
3	A <sub>1</sub> B <sub>3</sub> C <sub>3</sub>	140	26	6	20	26.0206
4	A <sub>2</sub> B <sub>1</sub> C <sub>2</sub>	160	22	5	54	34.6479
5	A <sub>2</sub> B <sub>2</sub> C <sub>3</sub>	160	24	6	20	26.0206
6	A <sub>2</sub> B <sub>3</sub> C <sub>1</sub>	160	26	4	23	27.2346
7	A <sub>3</sub> B <sub>1</sub> C <sub>3</sub>	180	22	6	26	28.2995
8	A <sub>3</sub> B <sub>2</sub> C <sub>1</sub>	180	24	5	24	27.6042
9	A <sub>3</sub> B <sub>3</sub> C <sub>2</sub>	180	26	4	21	26.4444

Table 5.3 S/N ratios values for the Impact strength

5.4 Impact Strength for Each Level of The Process Parameter

Taguchi Analysis: IMPACT versus AMPS, VOLT, TORAN

\* Note \*Design is not orthogonal.

Response Table for Signal to Noise Ratios Larger is better

LEVEL	AMPS	VOLT	TORAN
1	26.52	30.30	27.78
2	29.30	26.40	27.23
3	27.45	26.57	28.89
Delta	2.78	3.90	2.11
Rank	2	1	3

Table 5.4 Signal to Noise Ratios



LEVEL	AMPS	VOLT	TOR AN
1	21.33	35.00	24.50
2	32.33	21.00	23.00
3	23.67	21.33	31.33
Delta	11.00	14.00	9.33
Rank	2	1	3

Table 5.5 Response Table for Means

5.5 Main Effects Plot for Means

Main Effects Plot for SN ratios ,General Linear Model: IMPACT versus AMPS, VOLT, TORAN-Method  
Factor coding (-1, 0, +1),

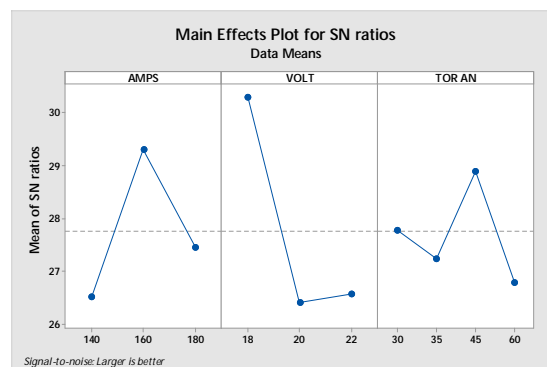
Factor	Type	Levels	Values
AMPS	fixed	3	140,160,180
VOLT	fixed	3	18,20,22
TOR AN	fixed	3	30,45,60

Table 5.6 Factor Information

Source	DF	Seq SS	Adj SS	F	P	% of Contribution
AMPS	2	218.4	109.21	0.64	0.662	24
VOLT	2	298.0	149.00	0.87	0.603	33
TORAN	2	188.4	62.81	0.87	0.802	22
Error	2	170.7	170.67			21
Total	8	943.6				100

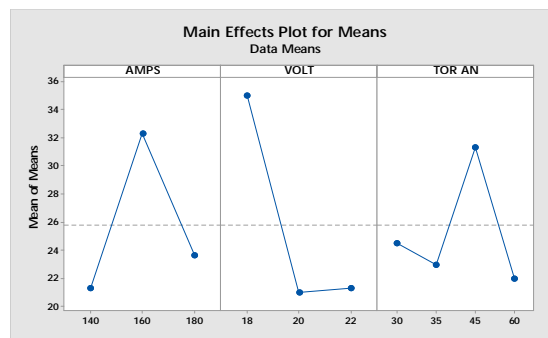
Table 5.7 Analysis of Variance

5.6 Graph for SN Ratio



Fig; 5.1 Main Effectsplot for SN Ratio(Mt)

5.7 Graph for Means



Fig; 5.4 Main effectsplot for means(Mt)

**VI. DEPTH OF PNETRATION**

Inadequate weld bead dimensions such as shallow depth of penetration may contribute to failure of a welded structure since penetration determines the stress carrying capacity of a welded joint .To avoid such occurrences the input or welding process variables which influence the weld bead penetration must therefore be properly selected and optimized to obtain an acceptable weld bead penetration and hence a high quality joint . To predict the effect of welding process variables on weld bead geometry and hence quality researchers have employed different techniques.



Fig 6.1 View of Test Plate -1

Peak Current-140, Basecurrent-18 , TORAN-30

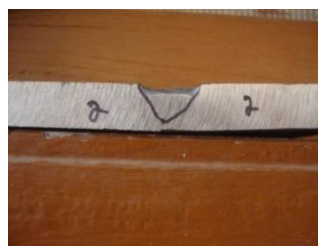


Fig 6.2 View of Test Plate -2

Peak Current-140, Basecurrent-20 , TOR AN -45





*Fig 6.3 View of Test Plate -3  
Peak Current-14 , Basecurrent-22 , TOR AN -60*



*Fig 6.4 View of Test Plate -4  
Peak Current-160, Basecurrent-18 , TOR AN -45*



*Fig 6.5 View of Test Plate -5  
Peak Current-160, Basecurrent-20 , TOR AN -60*

## VII. RESULT AND DISCUSSION

MIG welding can be used successfully to join EN8&OHNS. The processed joints exhibited better mechanical and metallurgical characteristics. The joints exhibited 90-95% of parent material's Hardness value. The specimen failures were associated depending upon the improper changes of heat value. The toughness value of the MIG welded dissimilar steel was comparatively higher value (180 AMPS VOLT-22 GAS PRESSURE 6 Kg/cm<sup>2</sup>) than other value. It also induces high tensile strength.

## VIII. CONCLUSION

Finally I concluded that in this project investigation the 180 AMPS VOLT-22 GAS PRESSURE-6Kg/cm<sup>2</sup> is the best parameters for Dissimilar-10 MM thickness plate for obtain the good weldment state. According to the Taguchis design and optimized parameter is value for Impact strength the 10 mm plate of dissimilar steel is 160 AMPS VOLT-22 GAS PRESSURE-6Kg/cm<sup>2</sup>

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