EXPERIMENTAL ANALYSIS TO IMPROVE DISSIMILAR WELDMENTS QUALITY AND SAFETY ASPECTS USING MODIFIED FLEX CORE ARC WELDING PROCESS

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ABSTRACT

The selection of improper FCAW process parameter increases the power consumption, material consumption, man power and cost of the product decreasing the weld quality. In order to obtain a good quality weld and control weld distortion, it is therefore, necessary to control the input welding parameters. In this research work, experiments has to be carried out on EN 8 & OHNS steel of 10 mm thick using FCAW process. The research will be applied Taguchi Method on different grade carbon steel specimen of dimensions 100 × 100 × 10 mm, which have following input parameters: various arc current arc voltage and gas pressure. The experiment has to be done in following aspects: Ultimate tensile strength. The main objective of the experimental factors affecting to mechanical property of dissimilar carbon grade steel on MIG welding machine with various welding parameters.

1. 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.

1.1FLUX CORE WELDING ROCESS

Flux core welding or tubular electrode welding has evolved from the 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

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 slagging 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.

In semiautomatic welding, the wire feeder feeds the electrode wire and the power source maintains the arc length. The welder manipulates the welding gun and adjusts the welding parameters. Flux-cored arc welding is also used in machine welding where, in addition to feeding the wire and maintaining the arc length, the machinery also provides the joint travel. The welding operator continuously monitors the welding and makes adjustments in the welding parameters. Automatic welding is used in high production

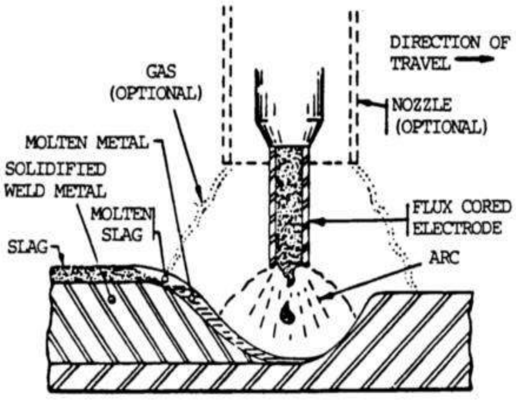


Figure 1.1Flux core Arc welding

2.WELDING PROBLEM ON DISSIMILAR STEEL

2.1 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.

2.2THE 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.

2.2.1 Carbon Rating There are different types of steel available, including several varieties of carbon steel. Low-carbon steel contains a maximum concentration of 0.3 percent carbon, while high-carbon steel contains a maximum concentration of 1 percent carbon.

2.2.2 Carbon in Steel

- Carbon strengthens steel, but also reduces its ductility, or pliability. The low ductility of high-carbon steel makes it more difficult to weld.

2.2.3 Effects of Welding on High-Carbon Steel

- When welding high-carbon steel, a high concentration of martensite may form in the weld. Martensite makes the metal extremely brittle, causing a weak weld that may break as soon as it cools.

2.2.4 Welding High-Carbon Steel

- According to ESAB Welding and Cutting, Inc., a low hydrogen electrode must be used when welding high-carbon steels. Additionally, annealing, or heating, the metal prior to welding slows the cooling process and prevents the concentration of martensite. Post heating will also reduce stress and strengthen the weld.

2.4 WELDING EFFECTS:

In the correct sense of the word, a defect is a rejectable discontinuity or a flaw of rejectable nature. Certain flaws acceptable in one type of product. A defect is definitely a discontinuity, but a discontinuity need not necessarily be a defect. Acceptance or rejection of flaws is based on different factors and to mention a vital few are:

- Stresses to which the parts will be subjected during service.
- Type of material used.
- The temperature and pressure to which the parts will be stressed.
- Its thickness.
- The environment (corrosive or non-corrosive).
- Safety.
- Consequences of failure.
- Cost and accessibility for repair, etc

Acceptance standards dictate the type of inspection and testing the weld is subjected to before giving a judgment. The quality control in charge shall analyse whether the flaws are inherent because of the process or are due to the processing or service conditions. It is of immense importance to see that the base material used for fabrication shall be of good quality and attested materials are demanded in the manufacture of space vehicles and ships, submarines, pressure vessels, power boiler components, heavy duty cranes, structures, bridges, etc, wherein the failure of weld will lead to loss of life, money and reputation.

The weld defects can be broadly classified into two types. They are:

- Planar defects/ two dimensional defects.

Voluminar defects / three dimensional defects.

Planar defects such as crack, lack of fusion, lack of penetration, severe undercut are critical in nature and involve lack of bonding and are not tolerated to any exent. Voluminar defects such as slag inclusion, cavities, pores ,etc are tolerated to a certain extent depending on the product class. Geometric defect such as excess reinforcement, under fill or under flush, root concavity are also permitted to a certain extent. If they from sharp notches, they are smoothened out wherever accessible to avoid stress concentration.

2.5 GENERAL REASONS FOR DEFECTS

The importance of weld quality is increasingly felt as we go ahead with the fabrication of sophisticated products using higher strength materials combined with critical design consideration. However, defects are likely to be present in materials produced at economic cost. Defects are generally introduced because of:

- Lack of know how and experience.
- Welding process characteristics.
- Base metal composition.
- Defective welding filler metals.
- Joint design.
- Welding environment (wind, fit up, temperature, etc.)

3. MATERIAL DETAILS

3.1 WORK MATERIAL DETAILS

- Work material –OHNS steel
- Work material size–100mm length 10 mm thickness
- Blanking and stamping dies, Punches, Rotary shear blades, Thread cutting tools, Milling cutters, Reamers, Measuring tools, Gauging tools, Wood working tools, Broaches, Chasers.
- An ideal type oil-hardened steel which is economical and dependable for gauging, cutting and blanking tools as well as can be relied for hardness and good cutting performance.

3.2 CHEMICAL PROPERTIES

Table 1 Chemical properties

C	Mn	Si	S	P	Cr
1.09	0.45	0.4	0.17	0.04	1.01

3.3 PHYSICAL PROPERTIES

- Physical properties of OHNS tool steels are given below:

Table 2 Physical properties

Physical properties	**Metric**	**Imperial**
Density	7.85 g/cc	0.284 lb/in3
Melting point	1421°C	2590°F

3.4 THERMAL PROPERTIES

- The following table shows the thermal properties of OHNS steels.

Table 3 Physical properties

Properties	**Conditions T (°C)**	**Max Treatment**
Thermal expansion 12 x 10-6/ºC	20-100	-

3.5 MECHANICAL PROPERTIES

- The mechanical properties of OHNS steels are tabulated below:

Table 4 Physical properties

Property	**Quality**
Max Hardness	60-64
Heat Resistance	Low
Wear Resistance	Medium
Machinability	Good
Deformation During Hardening	Medium
Hardening Temperature	760-870
Resistance To Decarburization	Good
Micro Hardness	280Vhn

3.5 APPLICATION

OHNS Material is used in tooling applications requiring a high degree of accuracy in hardening, such as draw dies, forming rolls, powder metal tooling and blanking and forming dies and bushes

3.6INTRODUCTION OF EN8 STEEL:

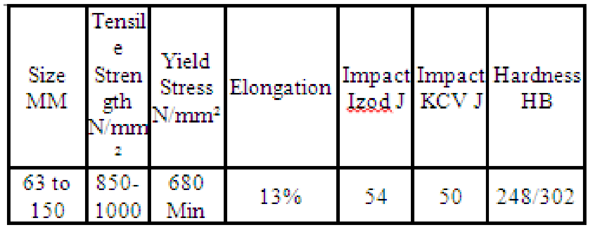
3.7 CHEMICAL PROPERTIES

Table 5 Chemical properties

SL.NO	ELEMENT	COMPOSITION IN WEIGHT %	
		MIN	MAX
1	Carbon, C	0.35	0.45
2	Manganese, Mn	0.45	0.70
3	Silicon, Si	0.1	0.35
4	Molybdenum, Mo	0.20	0.35
5	Chromium,Cr	.90	1.40
6	Sulphur&phosphorous		0.05

3.8 PHYSICAL PROPERTIES

Table 6 Physical properties



Size MM	Tensile Strength N/mm^2	Yield Stress N/mm^2	Elongation	Impact Izod J	Impact KCV J	Hardness HB
63 to 150	850-1000	680 Min	13%	54	50	248/302

4. DESIGN OF EXPERIMENT

Process parameters and their levels

Table 7 Process parameters and their levels

Levels	**Process parameters**		
	ELDING URRENT AMPS I	**ARC OLTAGE V**	**TORCH ANGLE Degree^O**
1	140	18	30
2	160	20	45
3	180	22	60

4.1 AN ORTHOGONAL ARRAY L9 FORMATION (INTERACTION)

Table 8 L9 Array formation

AMPS	VOLT	TORCH ANGLE
140	18	30
140	20	45
140	22	60
160	18	45
160	20	60
160	22	30
180	18	60
180	20	30
180	22	45

4.3 ROCKWELL HARDNESS TEST

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.. 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.The ball penetrators are chucks that are made to hold 1/16” or 1/8” diameter hardened steel balls. Also available are ¼” and ½” ball penetrators for the testing of softer materials.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. 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

Table 9 HARDNESS VALUE-HRB VALUE

SAMPLES	S1	S2	S3	S4	S5	S6	S7	S8	S9
EN8	90	95	87	90	94	92	95	87	89
OHNS	92	94	91	95	94	94	87	90	94

4.4 IMPACT TEST

Impact strength testing is an ASTM standard method of determining impact strength. A notched sample is generally used to determine impact strength. Impact is a very important phenomenon in governing the life of a structure. In the case of aircraft, impact can take place by the bird hitting the plane while it is cruising, during take - off and landing there is impact by the debris present on the runwayAn arm held at a specific height (constant potential energy) is released. The arm hits the sample and breaks it. From the energy absorbed by the sample, its impact strength is determined.The North American standard for Izod Impact testing is ASTM D256. The results are expressed in energy lost per unit of thickness (such as ft-lb/in or J/cm) at the notch. Alternatively, the results may be reported as energy lost per unit cross-sectional area at the notch (J/m² or ft-lb/in²). In Europe, ISO 180 methods are used and results are based only on the cross-sectional area at the notch (J/m²).

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").

The Izod impact test differs from the Charpy impact test in that the sample is held in a cantilevered beam configuration as opposed to a three point bending configuration.

4.5 IMPACT STRENGTH

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

Energy Range	=	0 – 300 J
Least Count (1 Division)	=	1J
Specimen size	=	10 X 10 X 55 mm
Notch	=	U NOTCH
Notch Depth	=	5mm

Table: 10 Impact Test

AMPS	VOLT	TORCH ANGLE	ENERGY OBSERVED IN JOULES
140	18	30	32
140	20	45	22
140	22	60	18
160	18	45	26
160	20	60	25
160	22	30	42
180	18	60	18
180	20	30	26
180	22	45	26

4.6 IMPACT SRENGTH (ANALYSIS OF RESULT)

Table: 11 HARDNESS AND S/N RATIOS VALUES FOR THE EXPERIMENTS

TRIAL NO.	DESIGNATION	AMPS	VOLT	TORCHANGLE	IMPACT SRENGTH	SNRA1
1	$A_1B_1C_1$	140	18	30	32	30.1030
2	$A_1B_2C_2$	140	20	45	22	26.8485
3	$A_1B_3C_3$	140	22	60	18	25.1055
4	$A_2B_1C_2$	160	18	45	26	28.2995
5	$A_2B_2C_3$	160	20	60	25	27.9588
6	**$A_2B_3C_1$**	160	22	30	42	32.4650
7	$A_3B_1C_3$	180	18	60	18	25.1055

8	**$A_3B_2C_1$**	**180**	**20**	**30**	**26**	**28.2995**
9	$A_3B_3C_2$	180	22	45	26	28.2995

4.7 IMPACT RESPONSE FOR EACH LEVEL OF THE PROCESS PARAMETER

Taguchi Analysis: HARD versus AMPS, VOLT, TA

Table: 12 Response Table for Signal to Noise Ratios

Larger is better

Level	AMPS	VOLT	TORCH ANGLE
1	**21.35**	**27.84**	**30.29**
2	**29.57**	**27.70**	**27.82**
3	**27.23**	**28.60**	**26.06**
Delta	**2.34**	**0.92**	**4.23**
Rank	2	3	1

Table: 13 Response Table for Means

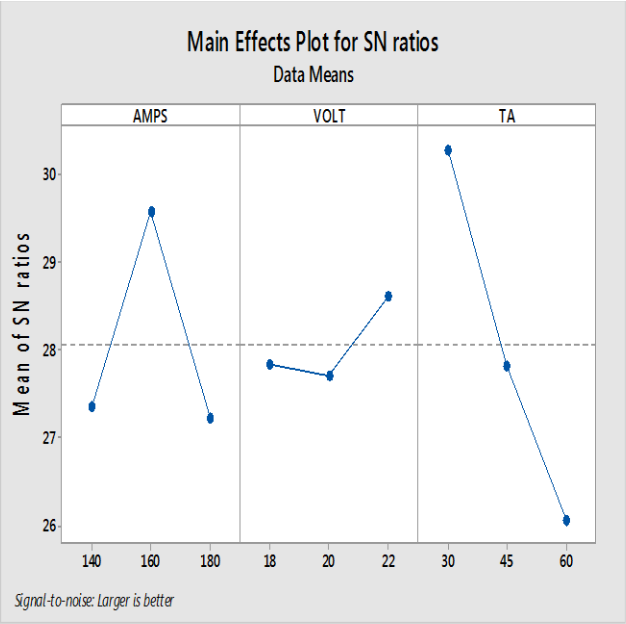
Factor	Type	Levels	Values
AMPS	fixed	3	140,160,180
VOLT	fixed	3	18,20,22
TA	fixed	3	30 45 60

Table: 14 Main Effects Plot for Means

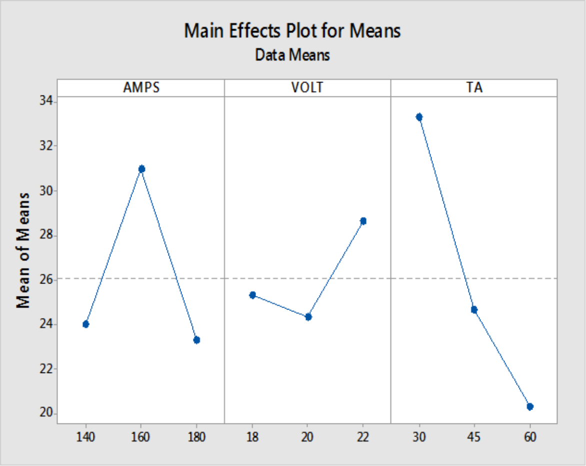
Level	AMPS	VOLT	TORCH ANGLE
1	**24.00**	**25.33**	**33.33**
2	**31.00**	**24.33**	**24.67**
3	**23.33**	**28.67**	**20.33**
Delta	**7.67**	**4.33**	**13.00**
Rank	2	3	1

Table: 15 Analysis of Variance

Source	DF	Seq SS	Adj SS	F	P	% OF CONTRIBUTION
AMPS	2	108.22	54.11	3.10	0.244	25
VOLT	2	30.89	15.44	0.89	0.530	7
TA	2	262.89	131.44	7.54	0.117	61
Error	2	34.89	17.44			7
Total	8	436.89				100



Main Effects Plot for SN ratios

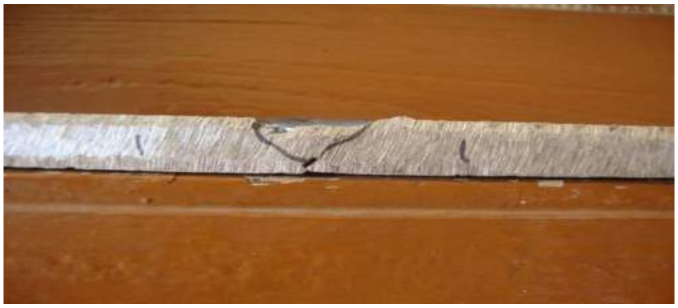


Main Effects Plot for means

4.8 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 .

4.8.1 VIEW OF TEST PLATE -1



AMPS- 140, VOLT-18, TA-30

VIEW OF TEST PLATE -2

AMPS- 140, VOLT-20, TA-45

VIEW OF TEST PLATE -3

AMPS- 140, VOLT-22, TA-60

VIEW OF TEST PLATE -4

AMPS- 160, VOLT-18, TA-45

VIEW OF TEST PLATE -5

AMPS- 160, VOLT-20, TA-60

VIEW OF TEST PLATE -6

AMPS- 160, VOLT-22, TA-30

VIEW OF TEST PLATE -7

AMPS- 180, VOLT-18, TA-60

VIEW OF TEST PLATE -8

AMPS- 180, VOLT-20, TA-30

VIEW OF TEST PLATE -9

AMPS- 180, VOLT-22, TA-45

4.8 VARIOUS SIZES OF BEAD WIDTH, DEPTH OF PENETRATION AND HEAT AFFECTED ZONE-EN8 FCAW

SAMPLES	Area	Mean	Min	Max	Angle	Length
S1	0.21	150.36	47.37	247.098	-1.051	11.722
	0.104	170.047	98.574	245.901	88.939	5.807
S2	0.139	122.071	74.333	233	0	7.742
	0.101	156.424	61.038	213.974	91.102	5.592
S3	0.204	103.544	85	204	180	11.398
	0.099	172.845	99.608	237.222	88.877	5.485
S4	0.208	82.707	60.667	171.667	180	11.613
	0.079	151.554	91.593	250	88.603	4.41
S5	0.259	105.927	75.811	236.256	-179.572	14.409
	0.1	132.172	21.333	216.333	90	5.591
S6	0.189	85.786	52.333	170	180	10.538
	0.083	159.003	47.132	209.302	88.668	4.625
S7	0.205	127.287	103.415	184.77	-0.541	11.398
	0.119	165.691	94	244	90	6.667
S8	**0.214**	**106.504**	**77.123**	**169.381**	**-2.064**	**11.943**
	0.124	**165.033**	**78.333**	**242.635**	**88.21**	**6.885**
S9	0.23	88.011	61.333	250.667	-1.444	12.8
	0.101	149.1	60.365	250.135	88.898	5.592

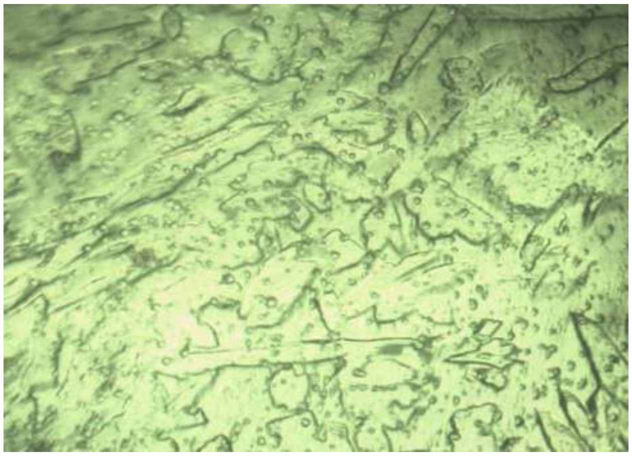
4.9 MICROSTRUCTURE

Microstructure is the characteristic appearance and physical arrangement of a metal as observed with a microscope. The microstructure of a material (of which we can broadly classify into metallic, polymeric, ceramic and composite) can strongly influence physical properties such as strength, toughness, ductility, hardness, corrosion resistance, high / low temperature behavior, wear resistance, and so on, which in turn govern the application of these materials in industrial practice.Micro-examination involves the study of the structures of metals and their alloys, also composites under a microscope at magnifications from X20 to X2000.The aim of micro-examination is

4.9.1 SEM ANALYSIS

The different micrographs of the tested samples were carried out using a JEOL-JSM 6510 LVSEM. The samples were loaded onto the sample holder and placed inside the SEM, adjustingthe working distance and hence the spot size the chamber was closed and vacuum wasapplied.

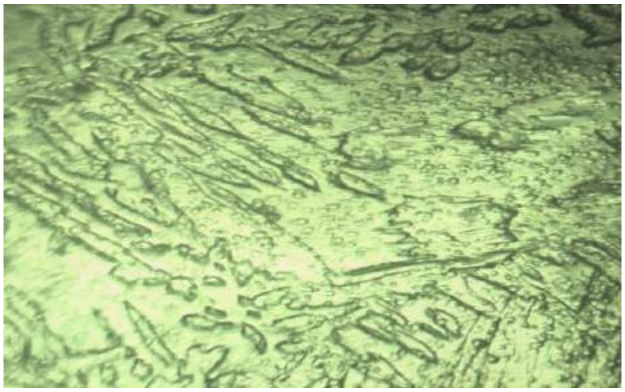
4.9.2 MICROSTRUCTURE -SAMPLE NO-3



Parameter

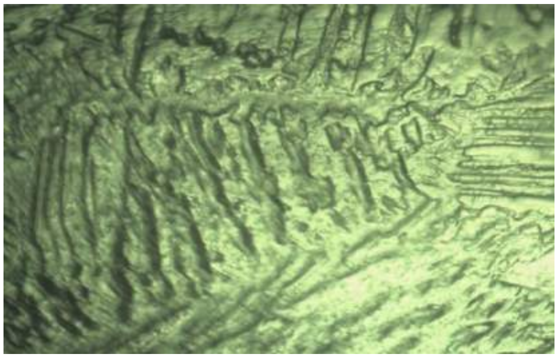
AMPS -140,VOLTAGE-22,TORCH ANGLE-60º
ETCHANT:10% Oxalic acid etch
Location:Weld Zone

4.9.3MICROSTRUCTURE IMAGES-SAMPLE NO-6



Micro Examination:
AMPS -160,VOLTAGE-22,TORCH ANGLE-30º
ETCHANT:10% Oxalic acid etch
Location:Weld Zone

4.9.4 MICROSTRUCTURE -SAMPLE NO-9



Micro Examination:
Parameter
AMPS -180,VOLTAGE-22,TORCH ANGLE-45º
ETCHANT:10% Oxalic acid etch
Location: Weld Zone

1.A slight grain coarsening at the heat affected zone (HAZ) of carbon steel and the presence of delta ferrite stringers at the HAZ of steel. formation of austenite matrix and vermicular

2.Delta-ferrite morphology in all the cases FCAW welding was seen. Weld microstructure was predominated with different forms of austenite, such as grain boundary austenite, Widmanstätten plates, and intragranular austenite.

tree like structure is Widmanstättensustenite

- dotdot cellular is intragranular austenite.

5. CONCLUSION AND RESULLT

From the investigation and mechanical property of FCAW butt welding of EN8&OHNS steel, conclusions were summarized as following The toughness value of the FCAW welded dissimilar steel was comparatively satisfied value (180 AMPS VOLT-20 TORCH ANGLE -30º) than other value. It also induces high tensile strength. Fianlly I concluded that in this project investigation the 180 AMPS VOLT-20 TORCH ANGLE -30º is the best parameter for EN8&OHNS –for10 MM thickness plate for obtain the good weldment state. According to the Taguchis design optimized parameter value for Impact strength for the 6 mm plate for EN8&OHNS – for 6 MM mm steel 160 AMPS VOLT-22 TORCH ANGLE-30º

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