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Parametric Optimization and Effect of Welding on the Tensile of MIG Welding a Galvanized Steelrod

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ABSTRACT: The S.S 316L may well be a chromium-nickel-molybdenum austenitic cemented steel made to permit made strides utilization security from S.S 304/304L in sensibly harming conditions. 316 stainless steel is chosen over unmistakable materials as a result of its unmistakable properties. At the point when are voltage was expanded from 26V to 32V, keeping gas stream rate at 25l/min and welding speed at 36cm/min then the penetration increases consistently with addition in voltage and goes to a biggest regard. When welding speed was increased from 27cm/min to 36cm/min keeping, gas flow rate at 25l/min and arc voltage at 32V then the welding speed isn't appearing any noteworthy impact on infiltration. At any current, globule width is conversely relative to the welding speed. Decrease in tallness can be due to the reality that weld pool measure is influenced by cooling rate, which diminishes with expanding the welding current or by diminishing the travel speed. When gas flow rate was increased from 20l/min to 25l/min keeping, welding speed at 36cm/min and arc voltage at 32V then gas flow rate shows no significant effect on both penetrations. The height is increasing, which may be due to the reason that the increased flow rate is providing space to in to increase.

KEYWORDS: Parametric Optimization, MIG Welding, Galvanized steel rod

I. INTRODUCTION

The S.S 316L may well be a chromium-nickel-molybdenum austenitic cemented steel made to permit made strides utilization security from S.S 304/304L in sensibly harming conditions. The advancement of molybdenum moves forward common utilization and chloride setting deterrent [1-3]. 316 stainless steel is chosen over unmistakable materials as a result of its unmistakable properties, less expensive fetched and its availability inside the publicize. 316 stainless steel utilized may be a evaporator audit steel utilized in weight vessels. This audit has tall disintegration resistance and can be worked at lifted temperature [9] Sort 316 stainless steel is broadly utilized in application requiring disintegration resistance predominant to Sort 304, or awesome lifted temperature quality. Commonplace livelihoods join exhaust manifolds, radiator parts, warm exchangers, fly engine parts, pharmaceutical and photographic equip, valve and pump trim, chemical adapt, digesters, tanks, evaporators, squash, paper and fabric planning gear Weld quality essentially depends on highlights of speck geometry, mechanical-metallurgical characteristics of the weld as well as on distinctive points of weld chemistry and these highlights are expected to be massively affected by diverse input parameters like current, voltage, anode stick-out, gas stream rate, edge arranging, position of welding, welding speed and various more in metal torpid gas (MIG) welding. Moreover, the total effect of the desired quality records chooses the degree of joint quality that got to meet the valuable points of view of the weld in down to soil field

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of application. Subsequently, course of action of a tastefulawesome quality weld shows up to be a challenging work. Examiners had done examinations on joining the 316L austenitic stainless-steel materials with utilize of MIG welding method, those are inspected underneath: Hu et al [1] utilized a high-precision appealing sensor to recognize the weld deserts in aluminium crushingblend welds. Lee et al. [2] have utilized the Taguchi procedure and backslideexamination in organize to optimize Nd-YAG laser welding parameters. A general arc welding process has been shown in figure -1.

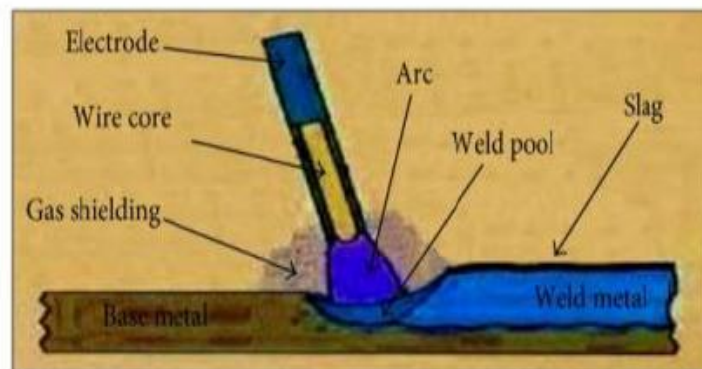


Fig -1. Welding process

1.1 Different type of welding processes

Based on the heat source used welding processes can be categorized as follows:

- (1) Arc welding process
- (2) Gas welding
- (3) Resistance welding
- (4) High energy beam welding
- (5) Solid state welding

1.1.1 Arc welding process

Among all these types of welding processes arc welding is widely used for different types of materials. Common types of arc welding process are:

- (a) Shielded Metal Arc Welding (SMAW) or Manual Metal Arc Welding.
- (b) Gas Metal Arc Welding (GMAW) or Metal inert or active gas welding.
- (c) Gas Tungsten Arc Welding (GTAW) or Tungsten Inert Gas (TIG).

1.1.1.a Fundamentals of MIG welding

This prepare is based on the guideline of creating weld by dissolving faying surfaces of the base metal utilizing warm created by a welding bend built up between base metal and a consumable terminal. Welding twist and weld pool are well secured by a fly of ensuring idle gas coming out of the gush and forming a cover around the twist and weld. MIG weld isn't considered as clean as TIG weld. Differentiate in cleanliness of the weld conveyed by MIG and TIG welding is fundamentally credited to the assortment in reasonability of ensuring gas to secure the weld pool in case of over two shapes.

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II EXPERIMENTAL PROCEDURE

1. INRODUCTION

MIG (Metal Dormant Gas) welding, additionally known as MAG (Metal Dynamic Gas) and inside the USA as GMAW (Gas Metal Arc Welding), could be a welding set up that is by and by comprehensively used for welding an arrangement of materials, ferrous and non-ferrous.

1.1 MATERIAL: HSLA STEEL (HIGH STRENGTH LOW ALLOY STEEL)

Evaluation type: 304L

Material composition: Carbon – 0.061, Manganese – 1.03, Sulphur – 0.04, Phosphorus – 0.036, Silicon – 0.46, Nickel -8.01, Chromium- 0.25, Hardness-156 BHN

HSLA Steel (high quality low compound steel) is a kind of steel composite that gives numerous advantages over standard steel combinations. When all is said in done, HSLA combinations are a lot more grounded and harder than normal plain carbon steels. In any case DCEN is used (for higher consume off rate) with certain self-securing and gas shield cored wires. DC yield control sources are of a transformer-rectifier plan, with a level trademark (predictable voltage control source). The principal normal kind of control source used for this get ready is the traded fundamental transformer rectifier with predictable voltage qualities outline both 3 phase 415V and 1-Stage 240V information supplies.

1.2 FILLER WIRE

Alright AUTROD 13.14

A Copper covered composite wire for MIG welding of HSLA steels.

Alright AUTROD 13.14 is a copper covered low compound wire for GMAW of HSLA steels, for example, tractor chamber, car piece, wagon producing.

1.3 TYPICAL WIRE STRUCTURE (%)

Carbon – 0.08, Manganese – 1.7, Silicon – 0.50, Molybdenum – 0.40, Phosphorus – 0.02
Sulphur - 0.02, Copper – 0.2

1.4 SHIELDING GAS FOR GMAW

Ensuring Gasses Argon and helium are the two lethargic securing gasses used for verifying the fluid weld pool. The inactive arrangement demonstrates that not either argon nor helium will react artificially with the fluid weld pool. Nevertheless, in organize to gotten the chance to be a conductive gas, that is plasma, the gas must be ionized. Unmistakable gasses require particular entirities of essentialness to ionize, and this is frequently estimated regarding the ionization imperativeness. For argon, the ionization essentialness is 15.7 eV. Helium, then again, has ionization essentialness of 24.5 eV. Along these lines, it is less requesting to ionize argon than helium.

III. OBSERVATION RESULTS AND ANALYSIS

1.1 WELD BEAD GEOMETRY AND SHAPE RELATIONSHIP PENETRATION

Passageway is the expel that the blend zone extends underneath the primary surface of the parts being welded. It is all around perceived that, increase in passageway is affected by welding current, twist voltage, and welding speed {4, 5,6,11,12,16,22,24 and 27}. The significance of penetration augments as the present level additions. All the over indicated examiners point by point similar discernments. As explained via Cary (4) the welding current and weld invasion relationship is about a straight line and is most feasible in controlling this weld trademark. In MIG welding of

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steel, it is watched that invasion increases with the addition of wire support rate, round section voltage, welding rate and spout to plate discrete and reduces with augmentation in terminal to work point, however gas N Stream rate has no effect on penetration.

1.2 HEIGHT

It is described as the most extraordinary inverse stature of the crown over the outside of the base plate. It gives the idea regarding the quantity of leaves required for filling behind a section weld and its convexity includes a facilitate association with the nature of the weld joint. Backing is affected by welding wire support rate, welding speed, roundabout section voltage, spout to plate evacuate, consume point and anode expansiveness. According to Tsegelsky (29) support should run in doubt be 20% of the plate thickness. Unreasonable fortress stature doesn't push ahead the nature of the weld yet as a general rule augments the anode use.

1.3 WIDTH

Globule width is the width of the metal store zone on plate over which the curve drive is discharged. It characteristics to the nature of the welded joints. Twist voltage fuses a noteworthy effect on spot width. Travel speed incorporates a for the most part straight line association with the speck width. As movement speed augments, the weld width reduces. Gurev and Stout (12) watched that in MIG Welding the dab width extended with growing the warm contribution inside the work piece. i.e., with either growing the round portion present or lessening the welding speed. It is point by point that the tall welding rate achieved in peaky, undermined globules, and keeping in mind that moo welding paces caused wide globules, which will in general spread on the work, which was explained by Houldcroft (13).

S.No.	V	S	G
	1	2	3
1	+	+	+
2	-	+	+
3	-	-	+
4	+	-	+
5	+	-	-
6	+	+	-
7	-	+	-
8	-	-	-

Table -1 Plan organise

1.4 WELD BEAD PROFILE

The cleaned and carved tests were mounted on the scanner and weld globule profiles were checked. The filtered for 8 runs as per the plan network are appeared. The globule geometry parameters i.e. entrance, support, globule width and weakening were decided utilizing Adobe trapeze artist computer program which was accessible on Web. Weld globule geometry reactions recorded are given in table. P1, P2, P3 are the distinctive entrance readings of the examples from the runs. Additionally, W1, W2, W3 are the readings for all the reaction parameters were recorded for eight runs.

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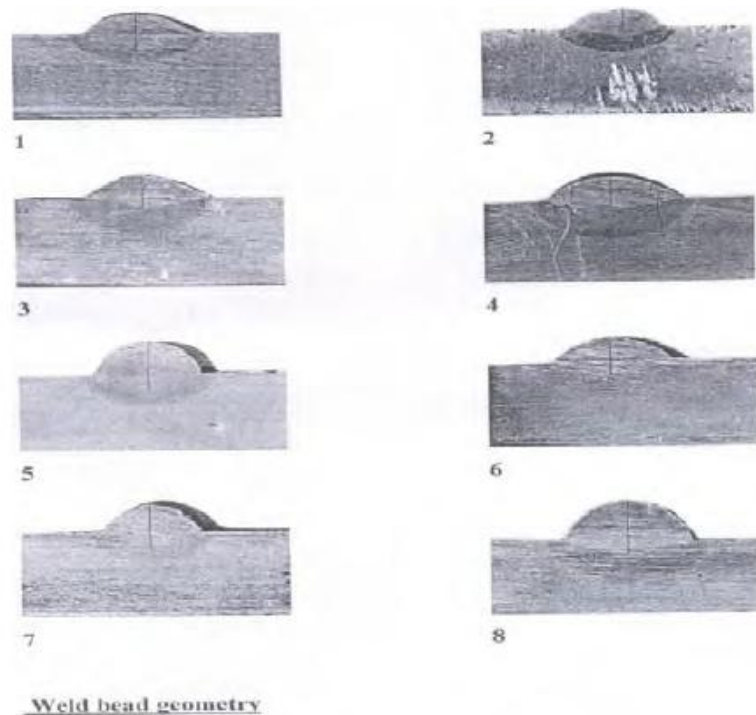


Fig-2 Represent weld bead geometry

1.2 SELECTION OF A MATHEMATICAL MODEL

A supportive method to survey the execution of numerical condition in showing the structure underneath assessment is through the idea of response surface strategy. It is acknowledged that there leave a couple of utilitarian relationship, for example, $Y = f(V, S, G)$ Which portrays the dependence of the response Y on the welding parameters V,S,G where these parameters have starting at now described in table. The response Y might be any of the speck parameters for example entrance, width height and so forth.

Condition likely could be made inside the edge out of a taking after polynomial.

$$Y = b_0 + b_1 V + b_2 S + b_3 G + b_{12} VS + b_{13} VG + b_{23} SG$$

or it can be written as,

$$Y = b_0 + b_1 V + b_2 S + b_3 G + b_4 VS + b_5 VG + b_6 SG$$

1.6 EVALUATION OF COEFFICIENTS

The regression coefficients of the selected model were calculated using equation. This is based on the method of least squares. A matrix designed to calculate the various regression coefficients of the model is given in table. The major aim of analysing data from designed experiments is to quantify and evaluate the importance of possible source of variation. This can be achieved through analysis of variance (ANOVA) associated with analysis of underlying model chosen.

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Estimated values of the coefficients of the models.

S.NO.	Coefficient	Weld bead geometry response		
		p	h	w
1	b_0	0.7825	1.6500	5.5113
2	b_1	0.0700	-0.2625	0.4788
3	b_2	0.0050	-0.1000	-0.2788
4	b_3	-0.0325	-0.0375	0.0988
5	b_4	-0.0075	-0.0125	0.1888
6	b_5	-0.0200	0.1250	-0.0838
7	b_6	0.0450	0.0125	-0.1663

Table 2 Represent estimated values of the coefficients of the models

1.7 DEVELOPED MODELS

These models for predicting different responses mentioned above are given below.

$$P = 0.7825 + 0.07V + 0.005S - 0.0325G - 0.0075VS - 0.02VG + 0.0450SG$$

$$H = 1.65 - 0.2625V - 0.1S - 0.0375G - 0.0125VS + 0.125VG + 0.0125SG$$

$$W = 5.5113 + 0.47788V - 0.2788S + 0.0988G + 0.1888VS - 0.0838VG - 0.1663SG$$

Estimated values of the response parameters calculated from these models are given below in Table 3. Details of the calculation have been shown.

S.NO	P	h	w
1	0.84	1.4	5.75
2	0.76	1.7	4.58
3	0.64	1.8	5.85
4	0.76	1.6	6.26
5	0.95	1.4	5.90
6	0.86	1.2	6.05
7	0.70	2.0	4.55
8	0.77	2.2	5.15

$$P = 0.7825 + 0.07V.$$

$$h = 1.65 - 0.2625V - 0.1S + 0.125VG$$

$$w = 5.5113 + 0.47788V - 0.2788S.$$

$$\% D = 30.9846 + 3.0333V.$$

Table-3 Represent Estimated values of the response parameters.

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1.8 SCATTER DIAGRAM

To guarantee the exactness of the created model and study the spread of qualities, results were plotted utilizing the disperse outline. The disperse chart for watched versus assessed estimations of weld dab entrance, tallness width and % weakening for various lines of the plan network is given in figure-4.2 to 4.5 individually. also, weld. MIG weld isn't considered as perfect as TIG weld. Distinction in tidiness of the weld created by MIG and TIG welding is basically ascribed to the variety in viability of protecting gas to ensure the weld pool in the event of over two procedures.

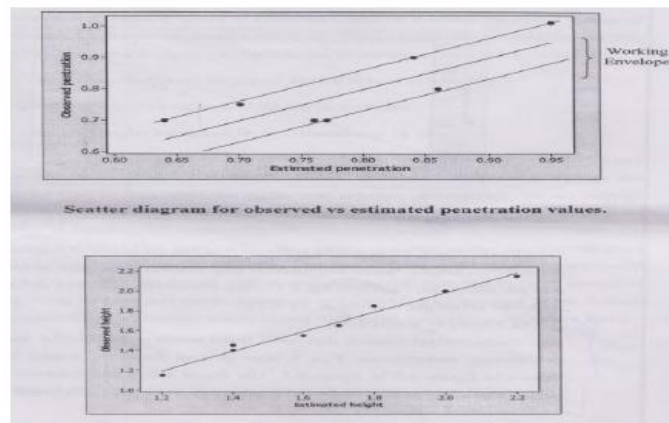


Fig-3 Scatter diagram for observed vs. estimated height values.

1.9 MICRO-HARDNESS TEST

Small scale hardness regard of the welded zone was estimated for all the welded models at the cross section to get it the modify in mechanical property of the welded zone. From the graph it is discovered that for almost all the test little scale hardness regard increases inside the welding zone than the base texture and hose esteems are inside the stretch out of 40 to 80 HV inside the welded zone.

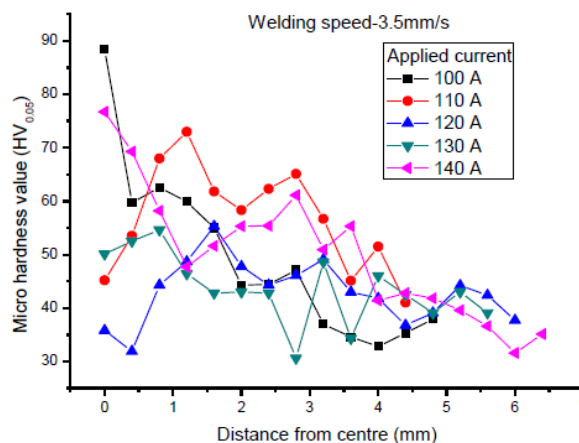


Fig- 4 Micro-hardness value from the centre of the weld zone towards the base material forwelding done with welding speed 3.5 mm/s and different welding current

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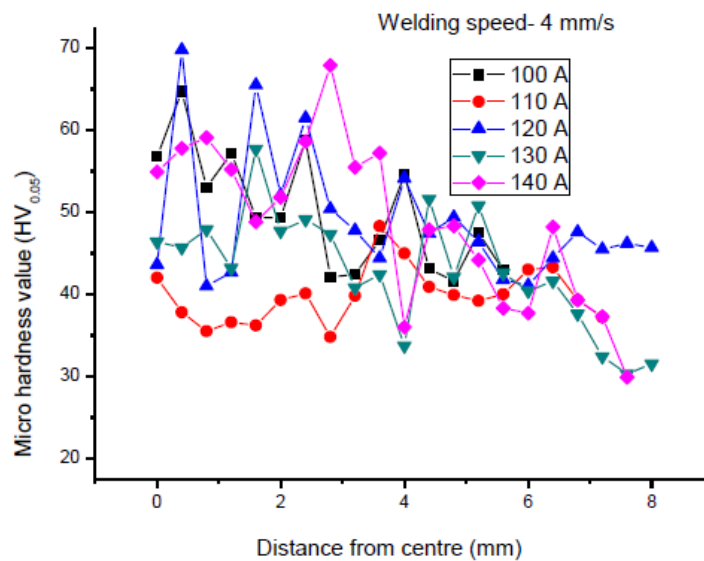


Fig-5 Micro-hardness value from the centre of the weld zone towards the base material for welding done with welding speed 4 mm/s and different welding current

1.10 TENSILE TEST

Flexible trial of the welded joint was performed with far reaching mouldable testing machine (Instron) with most extraordinary stack limit 600 kN. Stack furnish with a speed of 1 mm/min. From this diagram it is discovered that, welding finished with 4 mm/s there's no specific float in modify of malleable quality due to adjust in current. From the outset with augmentation current malleable nature of the welding additions up to 120 A and after that this regard lessens. Looking at the fig. 10 and 11 it is plainly observed that for almost all present setting condition (however 120 A present setting) pliable quality estimations of the welded joint performed with welding speed 3.5 mm/s are bigger than the malleable pressure estimations of the welded joint performed with welding speed 4 mm/s.

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Sample no	Load at tensile strength (N)	Actual tensile strength (MPa)
1	1719.36415	22.92486
2	1964.57603	26.19435
3	2878.42769	38.37904
4	2311.58920	30.82119
5	2927.50737	39.03343
6	1311.63038	17.48841
7	1285.78716	17.14383
8	3307.39478	44.09860
9	2258.41971	30.11226
10	1386.81158	18.49082

Table. 4 Tensile test

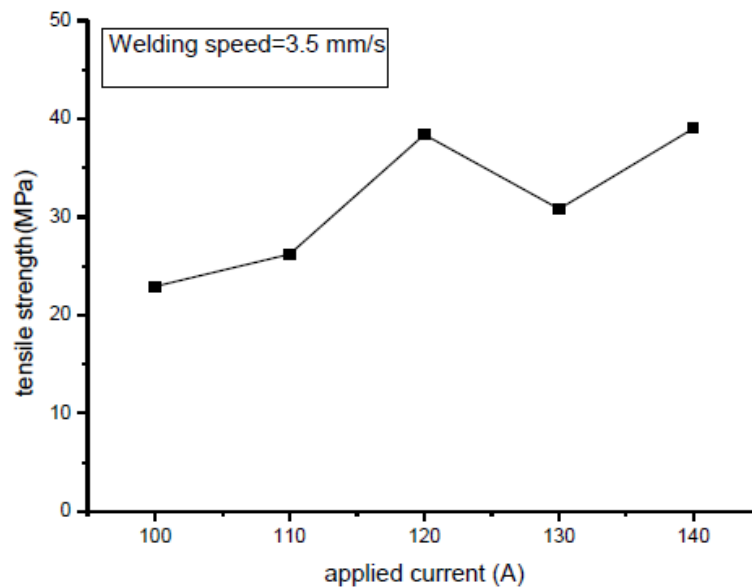


Fig-6 Tensile strength of the welded joint against applied current for welding speed of 3.5 mm/s.

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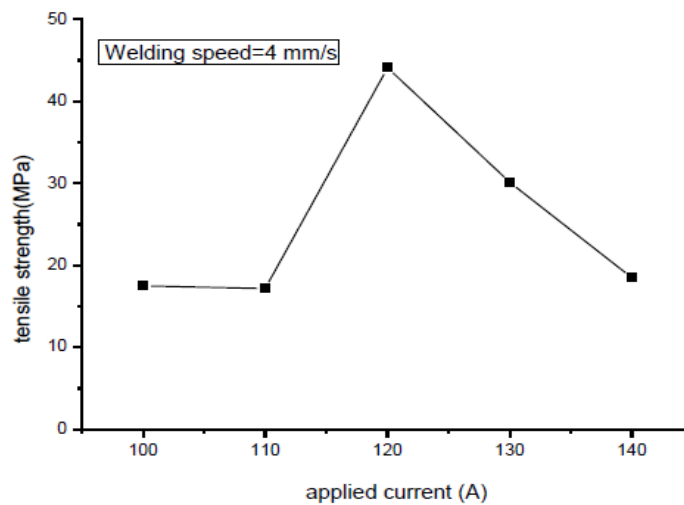


Fig-7 Tensile strength of the welded joint against applied current for welding speed of 4 mm/s

1.11 SECOND PHASE OF EXPERIMENT (BOTH SIDE JOINT)

After performing the 1st stage of experiments it was revealed that tensile strength of the weld joint is quite low and only part of the plate thickness got welded for the applied parameter setting and weld.

Exp. No.	Electrode Work piece Distance (mm)	Argon Gas flow rate (l/min)	Voltage (V)	Current (A)	Welding Speed (mm/s)
1	3	8-10	50	150	3.5
2	3	8-10	50	150	4
3	3	8-10	50	150	4.5
4	3	8-10	50	150	5
5	3	8-10	50	180	4.5
6	3	8-10	50	180	5
7	3	8-10	50	180	5.5
8	3	8-10	50	180	6

Table – 5 Experimental parameters for both sides welding by TIG welding

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In 2nd stage of explore welding done both side of plate. In this case, after performing welding at one side in butt condition, welding done at the other side with same parametric condition.

For all the tests, separate between terminal and work-piece kept steady at 3 mm, Ar gas stream rate was 8-10 l/min and connected voltage was 50 V.



Fig -8 Both side MIG welded samples prepared with (a) welding current 180 A, welding speed 3 mm/s (b) welding current 180 A, welding speed 3.5 mm/s

IV. ANALYSIS OF RESULTS

The numerical models that were fitted to the test information gave good connections. This is likewise clear from the dissipate outlines. The immediate impact and communication impact of different welding parameter on dot geometry have been examined as under:

1.12 EFFECT OF ARE VOLTAGE.

At the point when are voltage was expanded from 26V to 32V, keeping gas stream rate at 25l/min and welding speed at 36cm/min, and by encouraging the coded estimations of voltage, as appeared in table, the accompanying impacts were found.

1. The weld infiltration expanded from 0.64mm to 0.92mm.
2. The tallness diminished from 1.82mm to 1.28mm.
3. The dab width expanded from 4.26mm to 6.18mm.

The penetration increases consistently with addition in voltage and goes to a biggest regard. The stature reduces with addition in voltage yet the pivot is certified with the width and debilitating. Growing the round fragment voltage makes the globule increasingly broad, the stature is diminished since a similar volume of weld metal is incorporated. Most noticeable effect of individual parameter on spot width was of twist voltage. The augmentation in round section voltage achieved inside the addition in dab width from 4.26 to 6.18mm.

Voltage (Volts)	26	27.5	29	30.5	32
(Code)	-2.0	-1.0	0	1	2
P	0.6425	0.7125	0.7825	0.8525	0.9225
h	1.82	1.68	1.55	1.42	1.28
W	4.26	4.74	5.22	5.7	6.18

Table – 6 Effect of arc voltage on height, width and penetration

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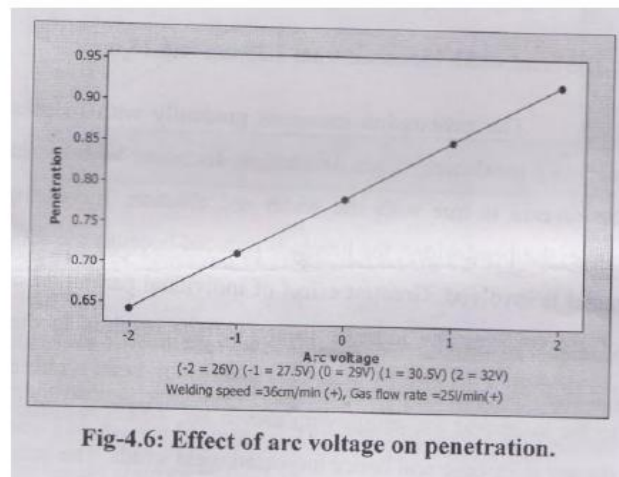


Fig-4.6: Effect of arc voltage on penetration.

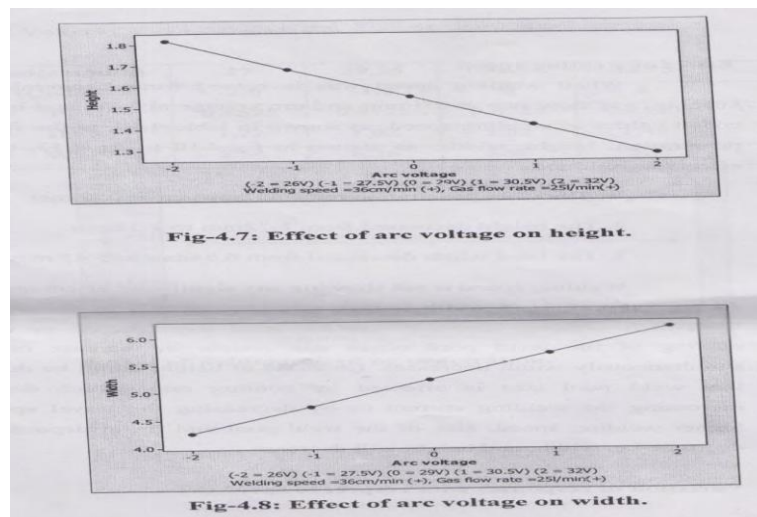


Fig-4.7: Effect of arc voltage on height.

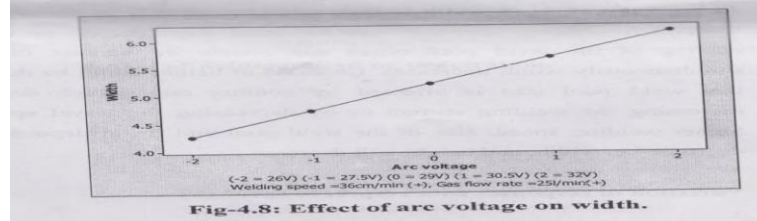


Fig-4.8: Effect of arc voltage on width.

Fig – 9 Effect of arc voltage on height, width and penetration

1.13 EFFECT OF WELDING SPEED

When welding speed was increased from 27cm/min to 36cm/min keeping, gas flow rate at 25l/min and arc voltage at 32V, and by feeding the coded values of welding speed, in the final model of penetration, height, width, the following effects were found

1. The weld penetration remains constant at 0.85mm.
2. The height decreased from 1.72mm to 1.32mm.
3. The bead width decreased from 6.45mm to 5.42mm.

Welding speed isn't appearing any noteworthy impact on infiltration. At any current, globule width is conversely relative to the welding speed. With tall welding speed, the overabundance weld metal builds up due to quick cooling of the weld pool edges and comes about in increment of stature and at the same time width diminishes. Decrease in tallness can be due to the reality that weld pool measure is influenced by cooling rate, which diminishes with expanding

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the welding current or by diminishing the travel speed. Hence at higher welding speed, estimate of the weld pool and metal testimony rate will diminish i.e. width, and stature will diminish.

Speed (cm/min)	27	29.25	31.5	33.75	36
(Code)	-2.0	-1.0	0	1	2
p	0.8525	0.8525	0.8525	0.8525	0.8525
h	1.72	1.62	1.52	1.42	1.32
w	6.45	6.26	5.98	5.7	5.42

Table -7Effect of welding speed on penetration

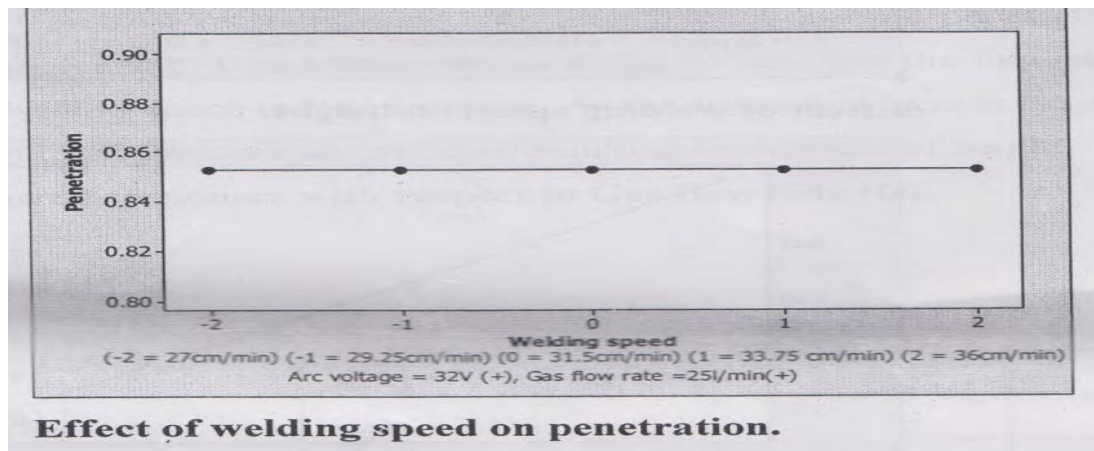


Fig- 10 Effect of welding speed on penetration

1.14 EFFECT OF GAS FLOW RATE

When gas flow rate was increased from 20l/min to 25l/min keeping, welding speed at 36cm/min and arc voltage at 32V and by feeding the coded values of gas flow rate , as shown in table – 4.11, in the final model of penetration, height, width, as shown in fig – 4.14 to 4.17, the following effects were found.

1. Bead penetration remains constant at 0.85mm.
2. The height increased from 1.04mm to 1.56mm.
3. The bead width remains constant at 5.7.

Gas flow rate shows no significant effect on both penetrations. The height is increasing, which may be due to the reason that the increased flow rate is providing space to it to increase. As the velocity of gas is increasing it is imparting low pressure on the bead, resulting in increase of height.

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Gas flow rate l/min)	20	21.25	22.5	23.75	25
(Code)	-2.0	-1.0	0	1	2
p	0.8525	0.8525	0.8525	0.8525	0.8525
h	1.04	1.17	1.3	1.43	1.56
w	5.7	5.7	5.7	5.7	5.7

Table- 8Effect of gas flow rate on penetration, bead width and height

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