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Optimization of MIG Welding Parameters for Improving Strength of Welding Joint for Husquarna- Pulley of Material SAE-1018

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Abstract: In this paper is used to study research work of Gas Metal Arc Welding(GMAW) show the effect of Current(A),Voltage(V),Gas Flow rate(L/Min) and Speed(M/Min) on Ultimate Tensile Strength(UTS) of SAE 1018 low alloy steel material, In this Experiment we done Experiment by using L9 orthogonal Array to find out UTS and also perform confirmatory Experiment to find out optimal run set of current, voltage speed and gas flow rate. Which is important to decide approach towards welding parameter validation? Effect of welding parameter also given in term of current, voltage, gas flow and wire feed. Also Taguchi method explains to optimization process. Root cause analysis done to know various factor and their effect on welding process

Index Terms: UTS, Weld Penetration, Taguchi Method, Welding Parameter Optimization, Root Cause Analysis, DMAIC.

I. INTRODUCTION

MIG welding is also recognized by gas metal arc welding. It is a semi-automatic process by which the arc length and feeding of wire into the arc can be controlled automatically and operator skills required to positioning the gun at a correct angle and moving it along the seam at a controlled travel speed in the metal transfer depends upon modular and spray transfer. The application of this process was for welding aluminum and As a result, the term MIG (Metal Inert Gas) welding was used and till now a days. Subsequent process developments included operation at low-current densities and pulsed direct current, application to a broader range of materials, and the use of reactive gases(particularly CO2) and gas mixtures.In this process consumable flux cored continuous wire or metallic electrode of diameter 0.8-2.4mm wound in spool form is fed at a required present speed through a welding gun, it picks up electric current from copper contact tube which is electrically connected to the DC power source and a shielding gases like argon, helium, carbon dioxide, carbon dioxide-argon mixture, argon-helium mixture. shielding gases are also use to cooled down the gun. MIG welding is use to increase productivity and consistency of quality.

II. PROBLEM IDENTIFICATION

Problem identification taken from industry by reviewing current process, rejection data, vender rating, customer satisfaction report and process owner comment about pain area. Here six sigma methodology was following to define exact problem. Generally according to six sigma DMAIC methodology to define problem and find appropriate solution.

Input Data received From Industry for Problem identification

Some data required to define problem and their exact root cause. Some quality tool can be used to arrange data and come on some conclusion. Seven Quality Control Tool can be to find out root cause of a problem. Here problem related welding was received from customer, nature of problem was shabby welding, blow hole, welding crack, spatter, un-fused wire, less penetration, fails in chisel test etc. rejection data collected from company. That data arrange as per below,

Rejection at Customer End				
Sr. No	Defect	Rej. Qty	cummulative	%cumml
1	Spatter	82	82	32.16
2	Shabby welding	42	124	48.63
3	Blow hole	40	164	64.31
4	Diameter over pin not ok	31	195	76.47
5	Un-fused welding wire	14	209	81.96

6	Under-cut	12	221	86.67
7	Diameter undersize	12	233	91.37
8	Keyway missing	12	245	96.08
9	Broken welding	10	255	100.00
	Total	255		

Table 1 Rejection at Customer End

Inhouse Rejection Data				
Sr.No.	Defect	Rejection qty.	Cumulative	% Cumulative
1	Spatter	252.00	252.00	25.48
2	Shabby welding	210.00	462.00	46.71
3	Blow hole	148.00	610.00	61.68
4	Diameter over pin not ok	140.00	750.00	75.83
5	Un-fused welding wire	127.00	877.00	88.68
6	Under-cut	50.00	927.00	93.73
7	Diameter undersize	50.00	977.00	98.79
8	Keyway missing	12.00	989.00	100.00
9	Broken welding	0.00	989.00	100.00
	Total	989		

Table 2 In-house Rejection Data

Pareto Chart For Customer Rejection

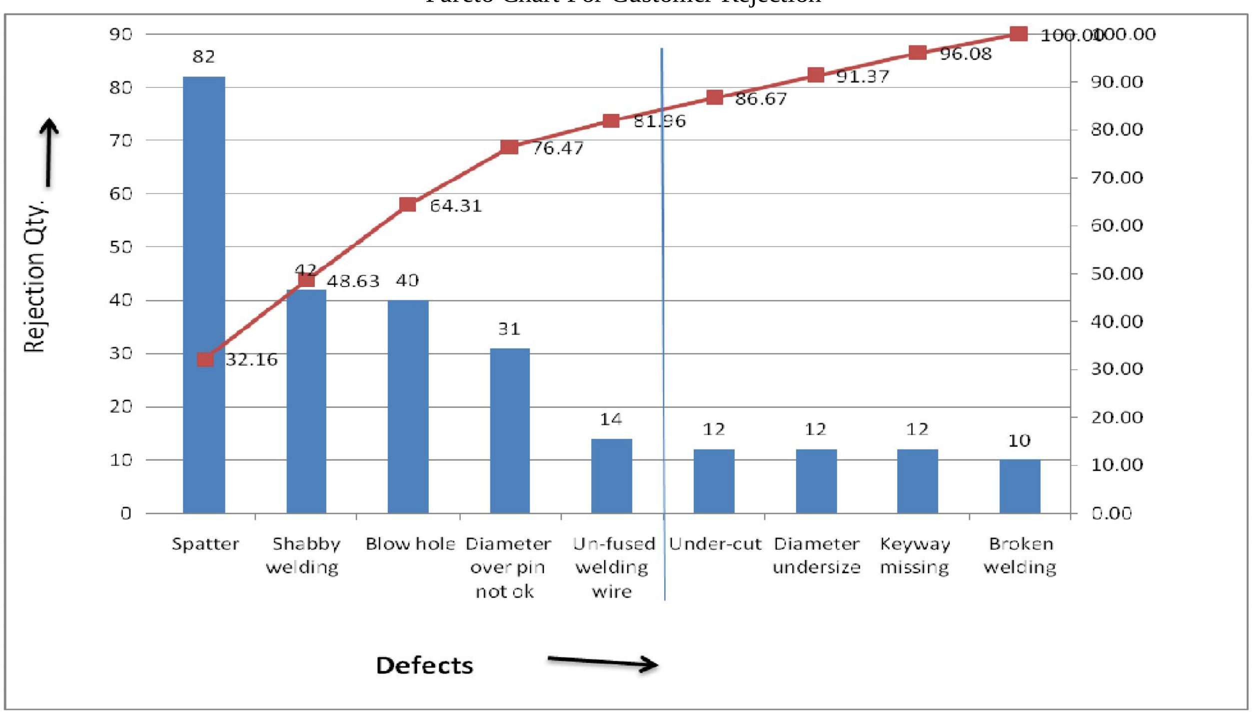


Fig.1. Pareto of rejection at Customer

Pareto Chart For In-house Rejection

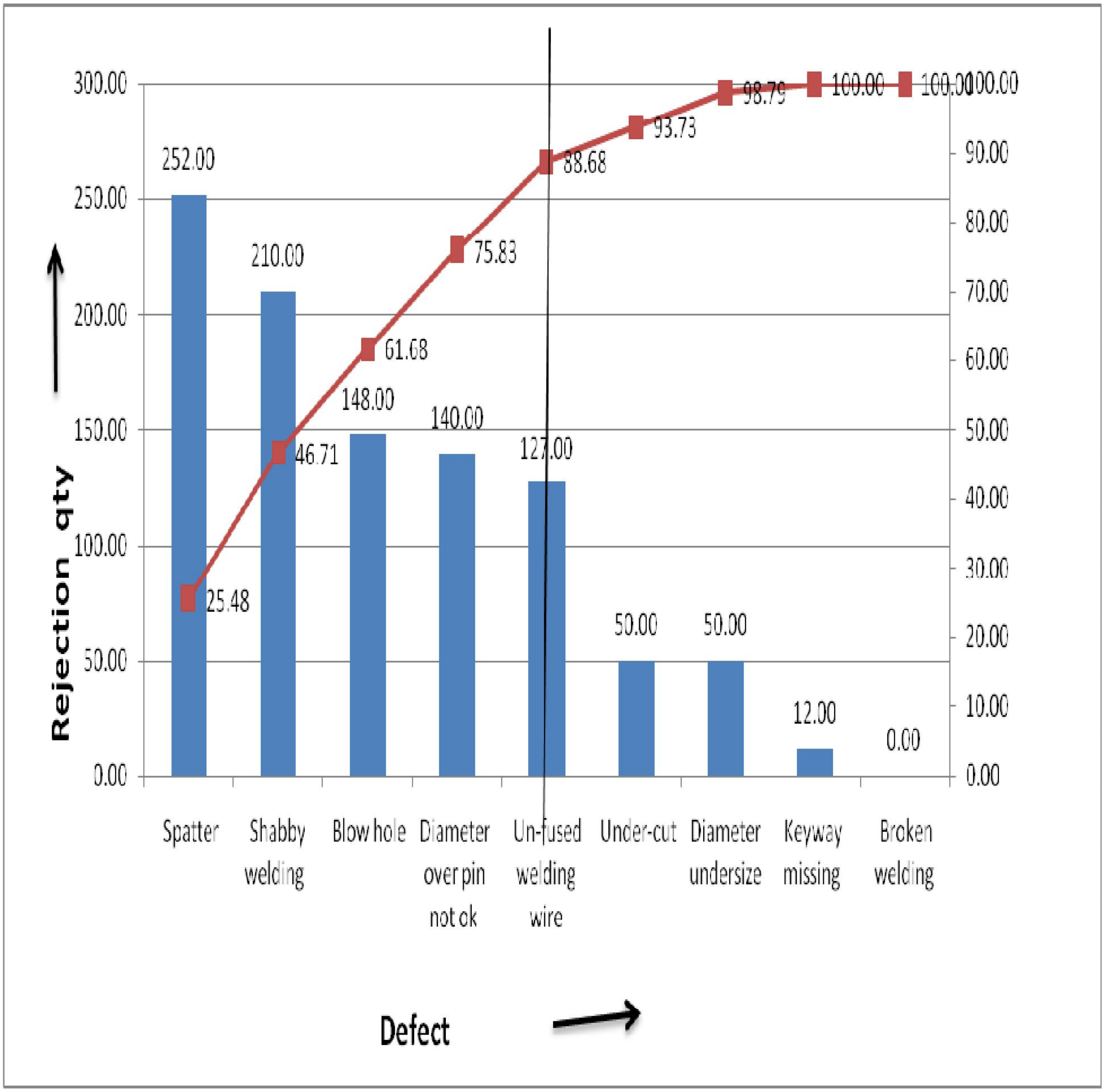


Fig.2 Pareto of rejection at In-house

From Pareto chart it is observed that most the defect contributing 80% of rejection from category of welding. Therefore the measure pain area is welding quality. Primary observation gives focus on welding quality and to define measure cause of defect depending on current process specification. It is need to verify existing system with control plan and thread to be find out. Some rejection noted of porosity found at welding section.

A. Root cause Analysis

For root cause analysis we are going to prepare cause and effect diagram. Generally we considering following parameters,

1) Man
2) Machine
3) Method
4) Environment

B. Cause and Effect Diagram

The major rate of defect is due to low skilled worker and no proper standards in production. Pareto Chart states that spatter, lack of fusion and crack are the three major defects. Process parameters play a vital role in eliminating the defects. From RCA, it is clearly visible that factors affecting defect rate.

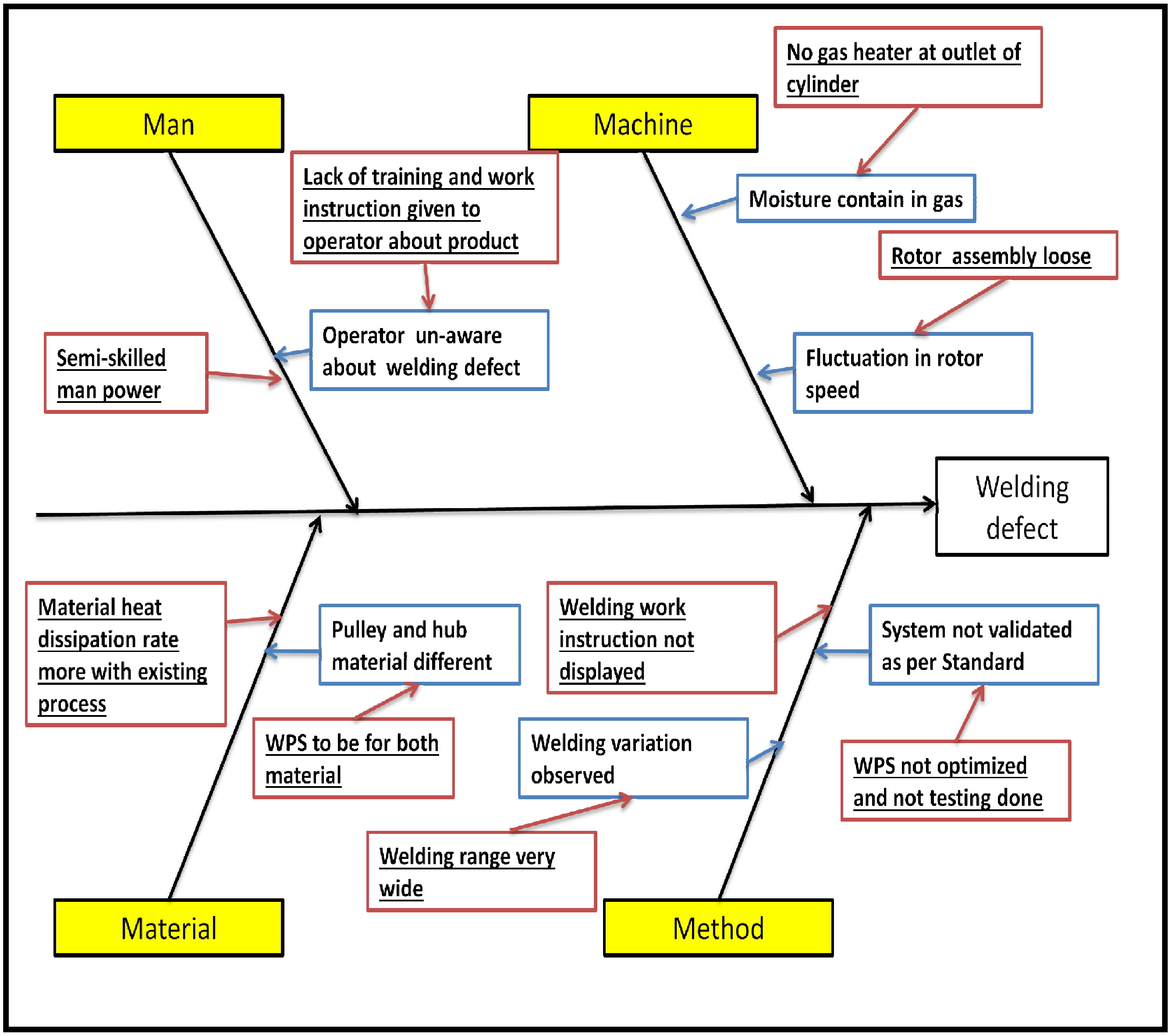


Fig 3. Ishikawa or Fishbone diagram

C. Root cause are as follows

1.No gas heater at outlet of cylinder. 2. Rotor assembly loose. 3.WPS not optimized and no testing done. 4.Welding work instruction not displayed. 5. Welding range wide. 6. WPS should such which match both material. 7. More heat dissipation. 8. Semi-skilled man power. 9. Lack of training material and aware to operator.

All root cause related with validation of welding process. Welding parameter should be studied and improve welding quality will tend to solve problem.

III. DESIGN OF EXPERIMENT USING TAGUCHI METHOD

Taguchi method used to optimize welding parameter on the basis of penetration and visual quality defect. Hence orthogonal array method used to solve problem. Here Taguchi method solved by using minitab-17 software which is gives good analytical result. And avoid so many equation calculation. Penetration test carried out in-house and final sample checked in lab.

A. Process variables and their values

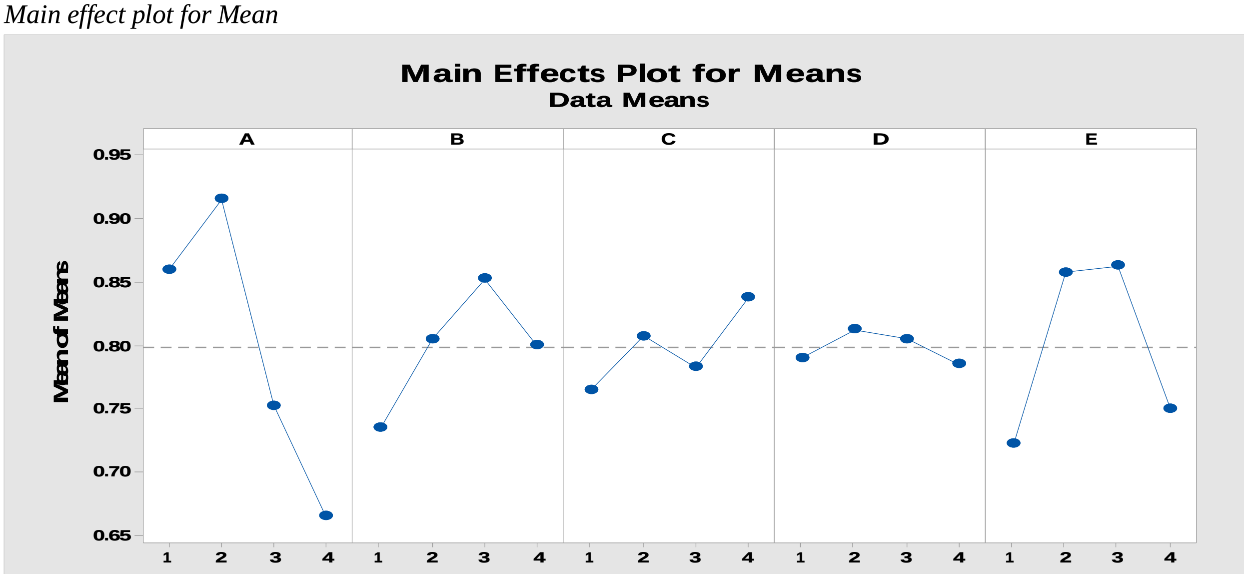
Factor	Affecting Factor	Level 1	Level 2	Level 3	Level 4
A	Wire feed (m/min)	2.8-3.2	2.8-3.2	3.0-3.2	2.8-3.2
B	current (A)	100-140	100-120	100-120	100-140
C	voltage (V)	18-24	20-22	18-24	18-20
D	Gas flow (Lit/min)	10-12	10-15	10-12	10-15
E	Machine speed (sec)	20-30	25-27	25-30	20-25

B. Orthogonal array and Mean of Penetration

A	B	C	D	E	Penetration	MEAN1
1	1	1	1	1	0.68	0.68
1	2	2	2	2	0.95	0.95
1	3	3	3	3	0.97	0.97
1	4	4	4	4	0.84	0.84
2	1	2	3	4	0.82	0.82
2	2	1	4	3	0.94	0.94
2	3	4	1	2	1.06	1.06
2	4	3	2	1	0.84	0.84
3	1	3	4	2	0.72	0.72
3	2	4	3	1	0.73	0.73
3	3	1	2	4	0.74	0.74
3	4	2	1	3	0.82	0.82
4	1	4	2	3	0.72	0.72
4	2	3	1	4	0.6	0.6
4	3	2	4	1	0.64	0.64
4	4	1	3	2	0.7	0.7

Table 3 Orthogonal array and Mean of Penetration

C. Main effect plot for Mean



D. *Factor Affected Level*

Response Table for Means (Result obtain by Minitab)

Level	A	B	C	D	E
1	0.8600	0.7350	0.7650	0.7900	0.7225
2	0.9150	0.8050	0.8075	0.8125	0.8575
3	0.7525	0.8525	0.7825	0.8050	0.8625
4	0.6650	0.8000	0.8375	0.7850	0.7500
Delta	0.2500	0.1175	0.0725	0.0275	0.1400
Rank	1	3	4	5	2

E. *Signal to Noise ratio (S/N Ratio)*

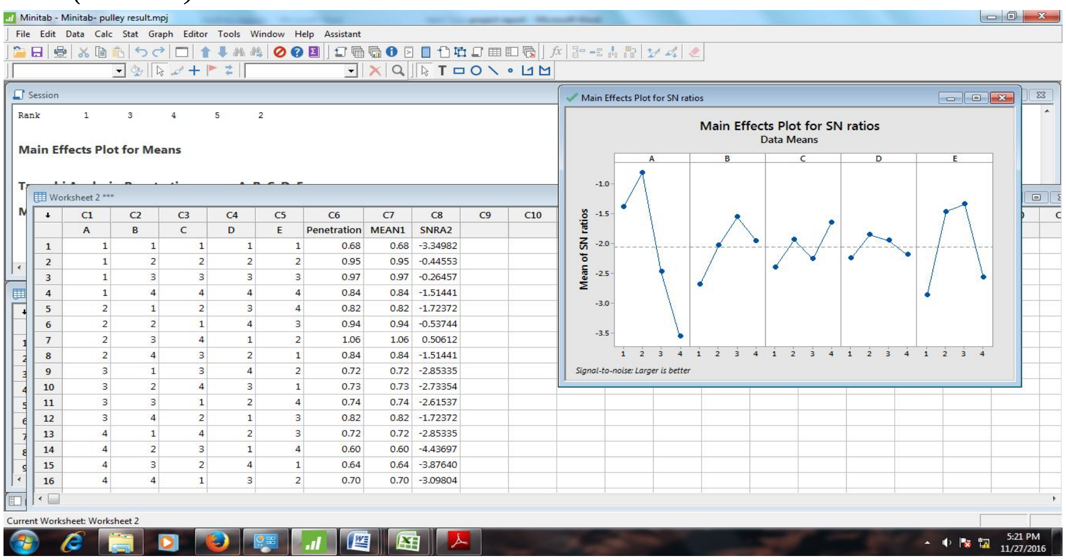


Fig.4 Evaluation of problem in Minitab

F. *Orthogonal Array with S/N Ratio*

A	B	C	D	E	Penetration	MEAN1	SNRA2
1	1	1	1	1	0.68	0.68	-3.34982
1	2	2	2	2	0.95	0.95	-0.44553
1	3	3	3	3	0.97	0.97	-0.26457
1	4	4	4	4	0.84	0.84	-1.51441
2	1	2	3	4	0.82	0.82	-1.72372
2	2	1	4	3	0.94	0.94	-0.53744
2	3	4	1	2	1.06	1.06	0.506117
2	4	3	2	1	0.84	0.84	-1.51441
3	1	3	4	2	0.72	0.72	-2.85335
3	2	4	3	1	0.73	0.73	-2.73354
3	3	1	2	4	0.74	0.74	-2.61537
3	4	2	1	3	0.82	0.82	-1.72372
4	1	4	2	3	0.72	0.72	-2.85335
4	2	3	1	4	0.6	0.6	-4.43697
4	3	2	4	1	0.64	0.64	-3.8764
4	4	1	3	2	0.7	0.7	-3.09804

Table. 4Orthogonal Array with S/N Ratio

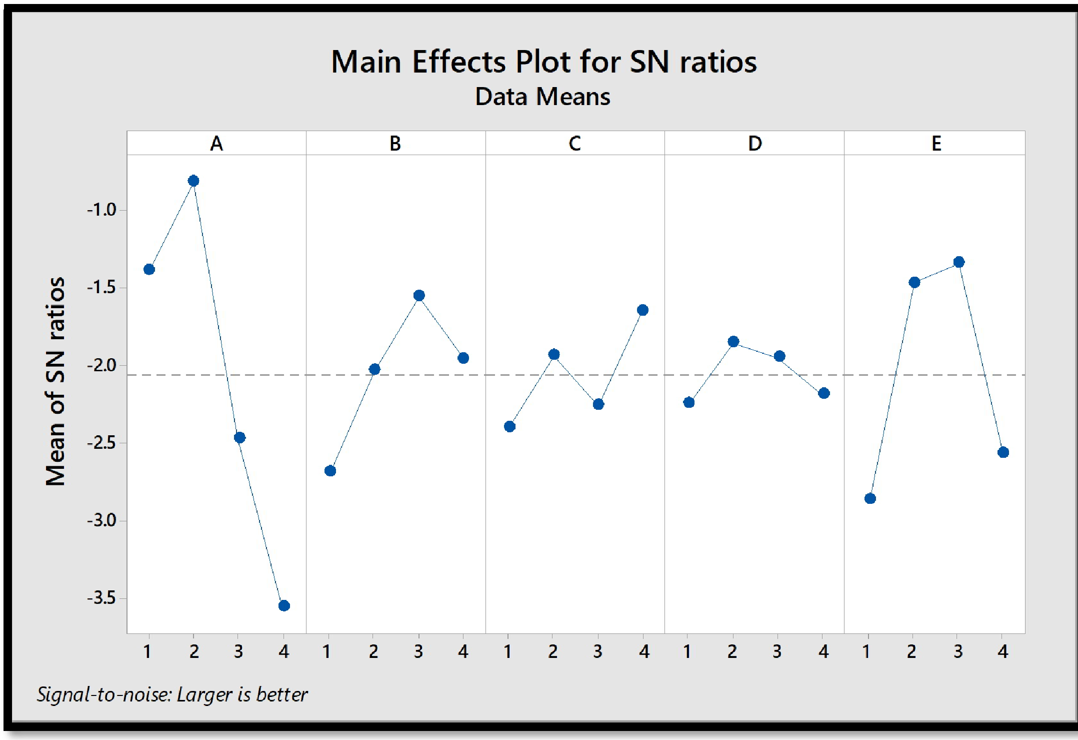


Fig. 5 Main effects plot for SN ratio.

A	B	C	D	E	Penetration	MEAN1	SNRA2
1	1	1	1	1	0.68	0.68	-3.34982
1	2	2	2	2	0.95	0.95	-0.44553
1	3	3	3	3	0.97	0.97	-0.26457
1	4	4	4	4	0.84	0.84	-1.51441
2	1	2	3	4	0.82	0.82	-1.72372
2	2	1	4	3	0.94	0.94	-0.53744
2	3	4	1	2	1.06	1.06	0.506117
2	4	3	2	1	0.84	0.84	-1.51441
3	1	3	4	2	0.72	0.72	-2.85335
3	2	4	3	1	0.73	0.73	-2.73354
3	3	1	2	4	0.74	0.74	-2.61537
3	4	2	1	3	0.82	0.82	-1.72372
4	1	4	2	3	0.72	0.72	-2.85335
4	2	3	1	4	0.6	0.6	-4.43697
4	3	2	4	1	0.64	0.64	-3.8764
4	4	1	3	2	0.7	0.7	-3.09804

Table. 5 Orthogonal Array with S/N Ratio

Bold highlighted showing the large signal to noise ratio (S/N ratio). Means that the seventh experiment set gives us good penetration result. Also welding defect analyzed with these sample having good quality.

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G. Result obtained for WPS

Parameter	Level
Wire feed (m/min) (A2)	2.8-3.2
current (A) (B3)	100-120
voltage (V) (C4)	18-20
Gas flow (Lit/min) (D1)	10-12
Machine speed (sec) (E2)	25-27

Table 6 Result obtained for WPS

Trial conducted for above parameter and observed welding defects. One lot 1000 nos. taken for trial and result stated as flows. It is also called as production trial result.

Rejection observed at Inhouse		
1	Shabby welding	1
2	Broken welding	Taken 15 part no any failure
3	Spatter	5
4	Under-cut	0
5	Blow hole	1
6	Un-fused welding wire	2
7	Diameter undersize	3

Table 7Rejection observed at In-house

1 Result:-Here welding parameter are observed as follows
Current:- 100-120 A
Voltage:- 18-20 V
Gas flow:- 10-12 Ltr /Min
Wire feed:- 2.8-3.2 M/Min
Machine Speed:- 25-27 Sec
Penetration requirement :- As customer requirement is 20% throat size

h >= 0.3 mm + 0.1 a, but max. 1 mm (both condition achieved)

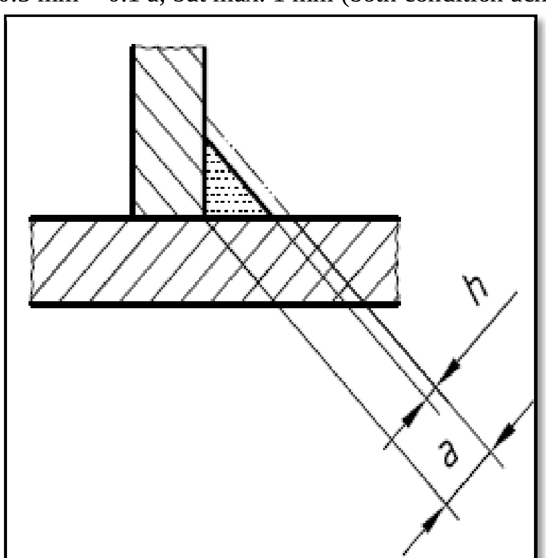

Fig. 6 Typical penetration schematics

IV. CONCLUSION

Taguchi optimization method was applied to find the optimal process parameters for penetration. A Taguchi orthogonal array, the signal-to-noise (S/N) ratio and analysis of variance were used for the optimization of welding parameters. A conformationexperiment was also conducted and verified the effectiveness of the Taguchi optimization method. The improvement of S/N ratio is -3.34982. The experiment value that is observed from optimal welding parameters, the penetration is 1.06 mm. & S/N ratio is 0.506117.

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