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Experimental Investigation of Mig Welding Parameters for Improving Strength of Welded Joints

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***Abstract*—The aim of the present study is to show the influence of different input parameters such as welding current, welding voltage and wire feed rate to identify the variations in the output responses such as Corrosion potential, grain area and hardness on mild steel using Metal Inert Gas Welding (MIG). Potentio-dynamic polarization studies are carried out to determine the pitting corrosion resistance. The selected three input parameters are varied at three levels. On the analogy, nine experiments are performed based on L9 orthogonal array of Taguchi's methodology in Minitab statistical software. Analysis of variance (ANOVA) is employed to find the levels of significance of input parameters.**

In this thesis, Welding voltage has significant effect on output responses when compared to welding current and wire feed rate. Response tables and graphs are used to find the single optimal responses using Minitab18 statistical software. Grey relational analysis has been carried out to find the multi response optimal parameters. The confirmation experiments are carried out to validate the optimal results.

I. Introduction

Welding is, at its core, actually a manner of bonding two portions of metallic. While there are different methods to join metal (riveting, brazing and soldering, as an example), welding has grow to be the approach of desire for its strength, performance and flexibility.

There are lots of different welding methods, and greater are being invented all the time. Some strategies use heat to basically soften pieces of metallic collectively, often adding a "filler steel" into the joint to behave as a binding agent. Other techniques depend upon stress to bind steel together, and nevertheless others use a aggregate of each warmth and stress. Unlike soldering and brazing, where the steel portions being joined continue to be unaltered, the method of welding always changes the work portions.

A. MIG Welding

MIG (Metal Inert Gas) welding, additionally called MAG (Metal Active Gas) and inside the USA as GMAW (Gas Metal Arc Welding), is a welding process this is now widely used for welding a diffusion of substances, ferrous and non ferrous. The crucial function of the manner is the small diameter electrode twine, that is fed constantly into the arc from a coil. As a result this process can produce quick and neat welds over a extensive range of joints.

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Equipment
● DC output energy supply
● Wire feed unit
● Torch
● Work return welding lead
● Shielding gas deliver, (usually from cylinder)

II. LITERATURE REVIEW

Optimization of mig welding technique parameters to expect maximum yield energy in aisi 1040 In this research work an try changed into made to expand a response floor model to predict tensile electricity of inert gas metallic arc welded AISI 1040 medium carbon metal joints. The method parameters inclusive of welding voltage, current, twine velocity and gasoline flow fee have been studied. The experiments were conducted based totally on a four-element, three-stage, face targeted composite layout matrix. The empirical courting can be used to are expecting the yield energy of inert gasoline metal arc welded AISI 1040 medium carbon metal. Response Surface Methodology (RSM) become applied to optimizing the MIG welding manner parameters to reap the maximum yield power of the joint.

Objective of the work
•Level of technique parameters is taken using Taguchi's L9 orthogonal method.
•Welding operation is achieved on mild metal specimen using MIG welding machine.
•Pitting corrosion capacity, hardness and grain location are measured for each specimen after the welding system.
•Analysis of variance is finished to recognize the stages of importance of every individual enter parameter on the output responses.
•Grey relational analysis is achieved to locate the multi response highest quality parameters. even if they have been submitted for publication, should be cited as "unpublished" [4]. Papers that have been

III. EXPERIMENTAL PROCEDURE

In this thesis, experiments are made to apprehend the impact of MIG welding parameters twine feed, welding cutting-edge and welding voltage on output parameters consisting of hardness of welding, microstructure, corrosion and gray realtion of welding.

MIG welding experimental pics.

MIG welding machine

Work pieces (mild steel)

Work pieces setup

For the experiment, welding parameters selected are shown in table.

TABLE I. THE WELDING CURRENT AND ELECTRODES CONSIDERED ARE

PROCESS PARAMETERS	LE VEL1	LEVEL2	LEVEL3
WELDING CURRENT (AMP)	200	220	240
WELDING VOLTAGE (V)	22	24	26
WIRE FEED RATE (m/min)	5	5.5	6

TABLE II. PARAMETERS

WELDING CURRENT (AMP)	WELDING VOLTAGE (V)	WIRE FEED RATE (m/min)
200	22	5
200	24	5.5
200	26	6
220	22	5.5
220	24	6
220	26	5
240	22	6
240	24	5
240	26	5.5

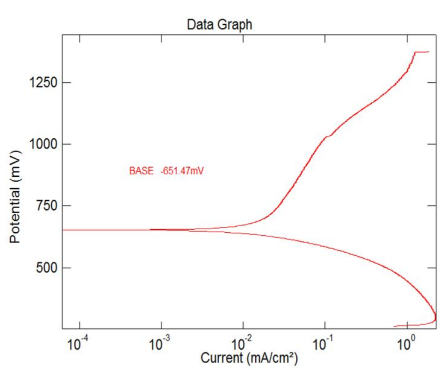
IV. TESTS CONDUCTED

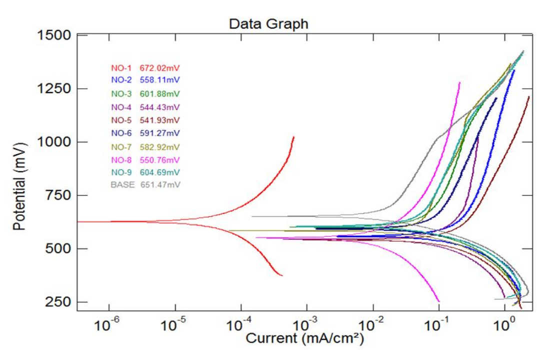
The following experimental exams are performed on the specimens which can be fabrication (welding).
•Electro chemical Corrosion Testing
•Microstructure
•Hardness
•Grey Relational Analysis
Electrochemical Corrosion Testing
All corrosion is an electrochemical method of oxidation and discount reactions. As corrosion happens, electrons are launched by using the steel (oxidation) and received by factors (discount) inside the corroding solution.

Corrosion Testing Equipment

Potentiostat

Polarization cell





V. Results and Discussion

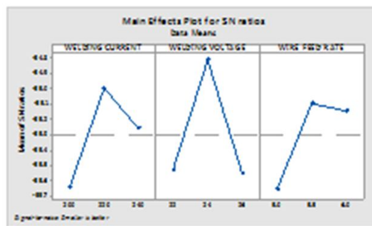
A. Results of Experimental Tests

TABLE III. ELECTROCHEMICAL CORROSION TESTING

Exp.No.	WELDING CURRENT (A)	WELDING VOLTAGE(V)	WIRE FEED RATE(m/min)	CORROSION POTENTIAL(mV)	SIGNAL/NOISE RATIO
1	200	22	5	672.02	-56.5476
2	200	24	5.5	558.11	-54.9344
3	200	26	6	591.27	-55.4357
4	220	22	5.5	544.43	-54.7188
5	220	24	6	541.93	-54.6789
6	220	26	5	601.88	-55.5902
7	240	22	6	582.92	-55.3122
8	240	24	5	550.76	-54.8192
9	240	26	5.5	604.69	-55.6307

TABLE IV. RESPONSE TABLE FOR SIGNAL TO NOISE RATIOS

Level	WELDING CURRENT	WELDING VOLTAGE	WIRE FEED RATE
1	-55.64	-55.53	-55.65
2	-55.00	-54.81	-55.09
3	-55.25	-55.55	-55.14
Delta	0.64	0.74	0.56
Rank	2	1	3



Main effect plot for Corrosion Potential

B. Microstructure Analysis

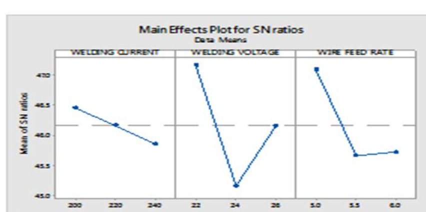
TABLE V. HARDNESS VALUES (BHN) ON WELD ZONE

SAMPLE No.	7.35kN	9.80kN	12.25kN
1	285	290	238
2	170	190	186
3	192	207	201
4	207	217	193
5	187	227	186
6	217	275	238
7	201	262	159
8	187	175	172
9	201	217	209

Exp.No.	WELDING CURRENT (A)	WELDING VOLTAGE(V)	WIRE FEED RATE(m/min)	BHN	SIGNAL/NOISE RATIO
1	200	22	5	285	49.0969
2	200	24	5.5	170	44.6090
3	200	26	6	192	45.6660
4	220	22	5.5	207	46.3194
5	220	24	6	187	45.4368
6	220	26	5	217	46.7292
7	240	22	6	201	46.0639
8	240	24	5	187	45.4368
9	240	26	5.5	201	46.0639

Table: Measured values and S/N Ratios for 7.35kN
Table: Response Table for Signal to Noise Ratios
Main effect plot for BHN

Level	WELDING CURRENT	WELDING VOLTAGE	WIRE FEED RATE
1	46.46	47.16	47.09
2	46.16	45.16	45.66
3	45.85	46.15	45.72
Delta	0.60	2.00	1.42
Rank	3	1	2



Optimal conditions: 200(A),22(V) and 5(m/min)

TABLE VI. ANOVA ANALYSIS FOR BHN

Source	DF	Adj SS	Adj MS	F- Value	P- Value	Percentage Contribution
WELDING CURRENT	2	571.6	285.8	0.35	0.742	6.629
WELDING VOLTAGE	2	3716.2	1858.1	2.26	0.307	43.103
WIRE FEED RATE	2	2689.6	1344.8	1.64	0.379	31.196
Error	2	1644.2	822.1			19.070
Total	8	8621.6				100

It is determined that welding voltage is the maximum prominent component which results hardness maximum with percent contribution of 43% accompanied by way of twine feed fee with percent contribution 31% then welding modern-day with percentage contribution 7%.

C. Grey Relational Analysis

RUN	Welding current (A)	Welding voltage (V)	Wire feed rate (m/min)	Corrosion potential (mV)	BHN	Grain Area (x 10-5 mm²)
1	200	22	5	672.02	285	4.582
2	200	24	5.5	558.11	170	4.56
3	200	26	6	591.27	192	4.107
4	220	22	5.5	544.43	207	4.702
5	220	24	6	541.93	187	4.364
6	220	26	5	601.88	217	3.79
7	240	22	6	582.92	201	4.163
8	240	24	5	550.76	187	4.388
9	240	26	5.5	604.69	201	4.184

RUN	S/N ratio			Normalized S/N ratio		
	Corrosion potential (mV)	BHN	Grain Area (x 10-5 mm²)	Corrosion potential (mV)	BHN	Grain Area (x 10-5 mm²)
1	-56.5476	49.0969	-13.2211	1.0000	1.0000	0.8801
2	-54.9344	44.6090	-13.1793	0.1367	0.0000	0.8578
3	-55.4357	45.6660	-12.2705	0.4050	0.2355	0.3725
4	-54.7188	46.3194	-13.4457	0.0214	0.3811	1.0000
5	-54.6789	45.4368	-12.7977	0.0000	0.1845	0.6540
6	-55.5902	46.7292	-11.5728	0.4877	0.4724	0.0000
7	-55.3122	46.0639	-12.3881	0.3389	0.3242	0.4353
8	-54.8192	45.4368	-12.8453	0.0751	0.1845	0.6795
9	-55.6307	46.0639	-12.4318	0.5093	0.3242	0.4587

TABLE VII. DEVIATION SEQUENCE AND GRA COEFFICIENT

RUN	Deviation sequence			GRA coefficient		
	Corrosion potential (mV)	BHN	Grain Area (x 10-5 mm²)	corrosion potential (mV)	BHN	Grain Area (x 10-5 mm²)
1	0.0000	0.0000	0.1199	1.0000	1.0000	0.8066
2	0.8633	1.0000	0.1422	0.3668	0.3333	0.7786
3	0.5950	0.7645	0.6275	0.4566	0.3954	0.4435
4	0.9786	0.6189	0.0000	0.3382	0.4469	1.0000
5	1.0000	0.8155	0.3460	0.3333	0.3801	0.5910
6	0.5123	0.5276	1.0000	0.4939	0.4866	0.3333
7	0.6611	0.6758	0.5647	0.4306	0.4252	0.4696
8	0.9249	0.8155	0.3205	0.3509	0.3801	0.6094
9	0.4907	0.6758	0.5413	0.5047	0.4252	0.4802

RUN	A	B	C	GREY RELATIONAL GRADE
1	1	1	1	**0.935529**
2	1	2	2	0.492884
3	1	3	3	0.431839
4	2	1	2	0.595010
5	2	2	3	0.434814
6	2	3	1	0.437941
7	3	1	3	0.441833
8	3	2	1	0.446779
9	3	3	2	0.470033

Grey relational grade showing optimal parameters

Multi optimal response A1B1C1

Determination of the Optimal Factor and its Level Combination The below desk suggests the Grey relational grades for minimum Corrosion capability (mV), most hardness(BHN) and minimal grain vicinity(mm2).

RUN	Parameters	Level 1	Level 2	Level 3	Max-Min
A	Corrosion potential (mV)	**0.6201**	0.4893	0.4529	0.1672
B	BHN	**0.6575**	0.4582	0.4466	0.2109
C	Grain Area (x 10-5 mm²)	**0.6067**	0.5193	0.4362	0.1706

Mean of all grey relational grades at level 1 in output response C

Consider grain area at level 1 : mean of (0.935529+0.437941+0.446779)= 0.6067

TABLE VIII. INPUT PARAMETERS AND OUTPUT RESPONSE

RUN	Welding current (A)	Welding voltage (V)	Wire feed rate (m/min)	Corrosion potential (mV)	BHN	Grain Area (x 10-5 mm^2)
1	200	22	5	672.02	285	4.582
2	200	24	5.5	558.11	170	4.56
3	200	26	6	591.27	192	4.107
4	220	22	5.5	544.43	207	4.702
5	220	24	6	541.93	187	4.364
6	220	26	5	601.88	217	3.79
7	240	22	6	582.92	201	4.163
8	240	24	5	550.76	187	4.388
9	240	26	5.5	604.69	201	4.184

Optimal Process parameters			
Level	A1B1C1 Predicted	A1B1C1 Experimental	%Error
Corrosion potential (mV)	695.0702	672.0200	3.31%
BHN	265.8889	285.0000	6.70%
Grain Area (x 10-5 mm^2)	4.6173	4.5820	0.76%

Confirmation Results
Predicted Response = Average of A1 + Average of B1 + Average of C1 – 2 x Mean of response (Yij)
Sample calculation for predicted results
Table: A1B1C1 values for BHN:

A1	B1	C1
285	285	285
170	207	217
192	201	187
215.67	**231**	**229.67**

Predicted Response = Average of A1 + Average of B1 + Average of C1 – 2 x Mean of response (Yij) 215.67+ 231+229.67 -2(205.22) = 265.9.

VI. CONCLUSION

Taguchi defines Quality Level of a product because the Total Loss incurred by using society due to failure of a product to carry out as desired when it deviates from the delivered target overall performance ranges.
From table, welding voltage has more significant effect(36%) on corrosion potential followed by welding current(22%) and wire feed rate(21%).The optimal parameters for corrosion Potential is 220(A) welding current,24(V) welding voltage and 5.5(m/min) wire feed rate. From table, welding voltage has more significant effect (58%) on grain area followed by wire feed rate(20%) and welding current(7%). The optimal parameters for grain area is 240(A) welding current,26(V) welding voltage and 6(m/min) wire feed rate. From table, welding voltage has more significant effect(43%) on hardness for load of 7.35kN followed by wire feed rate(31%) and welding current(7%). The optimal parameters for hardness of 7.35kN load is 200(A) welding current,22(V) welding voltage and 5(m/min) wire feed rate. The multi response optimization is carried out using Grey relational analysis and from table 20,it is observed that experimental run no.1 has highest grade ranking among the nine experiments. The multi response optimal parameter is determined at A1(200A),B1(22V) and C1(5m/min)The confirmation tests are carried out to validate the optimal results. The comparison shows good agreement between predicted values and experimental values.

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