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STAINLESS STEEL MIG WELDING PARAMETER OPTIMIZATION USING THE TAGUCHI METHOD

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Abstract:

MIG The gas flow rate, current, AC voltage, fill rod diameter, Electrode size, Arc travel speed, Electrode location, and Electrode extension all contribute to the final welded product's strength. However, gas velocity, voltage, and current are very significant variables. The effect of gas flow rate, current, and filler rod diameter on the strength of the weld for different materials has been the subject of much study. The influence of a parameter on the tensile strength of a weld specimen may be seen in the S/N ratio. The Taguchi technique was used to determine the optimal parameters for 1.9 orthogonal arrays.

Keywords: 1.9 orthogonal arrays, S/N ratio, UTM, SS-202, MIG

Welding

1 By using heat to cause fusion, welders link metals together. The junction is formed when molten metal is combined with a filler substance and then cooled. To protect the finished good from being oxidized or polluted, a welding shield is utilized. MIG arc, electric arc, gas flame, laser, electron beam, ultrasound, and friction are all viable energy options. Welding is possible in every environment, even air under pressure and outer space.

2 Geometry

Various weld joint are,

1. Lap joint
2. Butt joint
3. Corner joint
4. Edge joint and
5. T joint

The shape may be U and V Common welding joint types,

1. Corner weld
2. Lap weld
3. Fillet T weld
4. Full penetration T weld

5. Butt weld square joint
6. Butt weld V joint

3 Gas Metal Arc Welding (GMAW)

The two types GMAW are MIG welding, MAG welding. Here Electric arcs are formed between consumable MIG wire electrodes and the work piece that is generated and melt the metal and join. Through the wire electrode a shielding gas feeds through the welding gun. The process can be automatic or semi-automatic. A constant current and alternating current may be used. The metal transfer may be four types,

1. Short circuiting
2. Globular
3. Pulsed spray and
4. Spray

Steel is having fasting welding time compare with other metals.

The cost of inert gas is limited by the use of semi-inert gas CO_2. Now the preferred weldingis GMAW, because of its versatility, speed and the relative ease of adapting the process to robotic automation.

4 Development of GMAW

It was started on 19^{th} century by Hamphry, after Hamphry the short pulsed electronic arc was discovered by Davy on 1800. Continuous electric arc is used in 1802 by Petrov.

Initially carbon electrodes were used in carbon arc welding on 1890. In the year of 1920 metal electrodes has been invented by Nikolay. An early predecessor of GMAW was invented by P. O. Nobel. The direct current with a bare electrode wire is used to regulate the feed rate. It that time shielding gas was not used to protect the weld upto the later decade. In the year of 1948, GMAW was developed by Battelle Memorial Institute. Here a small diameter electrode and a constant voltage power source developed by H.E. Kennedy. It creates high deposition rate, bur the cost of inert gas is high.

In 1953 CO_2 was used in welding. In 1958 and 1959 short arc variation of GMAW was released, which increase the versatility and the ability to used thin materials.

GMAW is most suitable for industrial application mainly in sheet metal and automobile industry. It is also popular for automated welding, where robots handle the work pieces and the welding gun to accelerate manufacturing.

5 Applications

It is mainly used in Industry particularly Pipe line, Ship, Sheet metal, Boiler or Steel structures and Automobile and Home improvement sector industry.

6 Stainless Steel families

1. Austenitic stainless steel
2. Ferritic stainless steel
3. Martensitic stainless steel
4. Duplex stainless steel

7 Stainless Steel – 202

Similar to A 240/SUS 302 SS, it is a Cr-Ni-Mn Stainless. Low temperatures bring forth SS 202's exceptional toughness. It's durable, resistant to corrosion, and strong because to its high precipitation hardening grades. When machined, grade 202 stainless steel forms lengthy, sticky chips. Even in its annealed state, that can be machined. To achieve complete martensite condition during heat treatment, the material must be soked at 10380C (19000F) for 30 minutes before being cooled to below 160C (660F). The only way to connect this metal is using Oxyacetylene. AWS E/ER630 is suggested as a filler. Soaking for an hour at 11770C (21500F) is necessary before forging. Below 10100C (18500F), forging is not recommended.

8 Lecturer Survey

- S. V. Sapakal et al [1] et al. has done the work MS C20 material and optimize the welding parameters such as welding current, welding voltage, welding speed.by Taguchi Orthogonal array.
- \Raghuram Pradhan et al [2]. Investigated TIG and MIG welding on SS grades 202 & 304 of dimensions (40×50×6) mm. TIG uses argon and helium gases to protect the weld pool while MIG uses CO2gas. The tensile value, bending value MIG is higher than the TIG. But the grain size is different.
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- K. Arul Raj et al [8] investigate minimum wear rate for Taguchi method on orthogonal array and S/N ratio was employed to investigate wear behaviour of AISI 202. It was done above 400^0C.

9 Taguchi Method

Steps involved in Taguchi method,

1. Identify the main function and side effects.
2. Identify the noise factors, testing condition and quality
3. To find objective function to be optimized
4. Identify he control factors and their levels
5. Select a suitable Orthogonal Array and construct the Matrix.
6. Conduct the Matrix experiment.
7. Examine the data; predict the optimum control factor levels and its performance.
8. Conduct the verification experiment

Table No.1 L9 orthogonal array

Sl.No.	A	B	C
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

The following process parameter are studied for the

1. Welding Current (amp)
2. Arc Voltage (volt)
3. Gas Flow Rate (lit/min)

10 MIG welding

It is a process in which electric arcs are formed between consumable electrode and work piece.

11 Equipment needed

1. Welding gun
2. Welding power supply
3. Welding electrode wire
4. Shield

12 Welding gun and wire feed unit

Welding gun consist of,

1. Contact tip
2. Control switch
3. Gas nozzle
4. Power cable
5. Electrode conduit and linear
6. Gas hose
7. The shielding gas flow
8. Wire feed unit
9. Electric power

Contact tip is need up of copper and is connected to the welding power source through power cable and transmits the electrical energy to the electrode while directing it to the weld area. On the way to contact tip, the electrode conduit linear protects and guides the wire, which helps from shielding and uninterrupted wire feed, through the nozzle only shield gas flows into the welding zone. Consistent flow is must require for wire flow, which is molten weld pool.

The gas is supplied to the nozzle from tank of shielding gas with hose. Some times which hose is used to cool the gun. The electrode is supplied by wire fixed unit driving it throughthe conduct and on to the contact tip , feed rate of wire can vary with respect to are length and voltage. Wire fed rate is 30m/min, but feed rate for semi-automatic GMWA range from 2 to 10m/min.

13 Tool Style:

The Semi-automatic air cooled holder is generally used pressurized air is sent to through circulates to maintain moderate temperatures.

Lap and Butt joints are in need of lower current levels to make. The second type of electrode holder is semi-automatic water cooled type. High current is needed for welding T or corner joints. The third type is water cooled automatic electrode holder.

14 Power Supply

A large change in heat input and current in case for any change in arc length. The wire electrode melt quickly due to shorter are length/ the arc length must be a constant. To achive this constant power source is used in combination with an are voltage controlled wire feed unit.

The arc length is maintained by adjusting wire feed rate. Rarely the coupled effect of constant power source and constant wire feed rate is rarely used. Alternating current rarely used with GMAW instead of that DC is employed and the electrode is positively changed. Faster melting of feed wire is created by high heat concentration of anode which increases welding speed and weld penetration. While using special emissive coated electrode the polarity can be reversed. A negatively charged electrode in rarely used.

15 Electrode

The electrode metal and size is based on the metal being welded joint design, process variation and material surface condition. Electrode selection is based on the mechanical properties of weld and weld quality finally finished metal have the same property of base metal with no defects such as discontinuities and porosity. To prevent oxygen porosityelectrodes must contain Si, Mn, Ti and Al. To avoid nitrogen porosity Ti and Zr are used. Thediameter of electrode may vary from 0.7 to 2.4 mm. Smallest electrodes generally upto 1.14 mm.

16 Shielding Gas

It is necessary for gas metal arc welding to prevent the welding area from atmosphere gas such as N^2 and O^2.

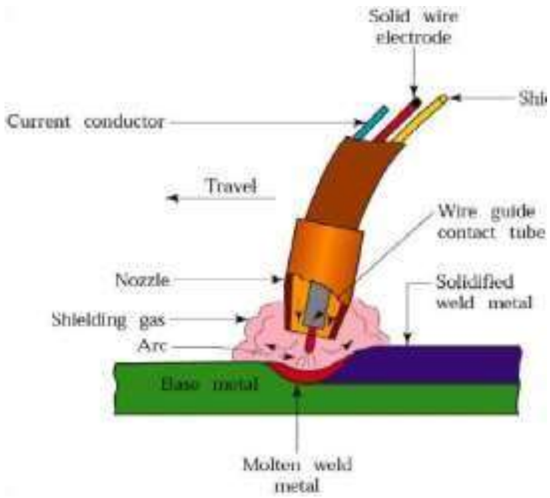

Figure 1 GMAW System setup

17 Welding Process

Butt joint has been made under various condition of welding as given L9 orthogonal array of Taguchi method.

Figure 2 Before Welding

Figure 3 During Welding

Figure 4 After Welding

18 UTM

It is used to that the tensile strength and compression strength of a metal. It consists of twounits namely,

1. Loading unit 2. Control Panel

Loading Unit

It consists of hydraulic cylinder with robust base side. The piston reciprocates up and down. In the left hand side the chain drive electric motor is available. The screw column maintained in the base can be rotates by mean of chain arrangement. There is a connection between lower table and upper head assembly which moves the piston up and down. Number bearings carry the assembly which slides over the column.

Control Panel

It has oil tank having slight glass to which the oil level. The displacement type pump has plunger. The pump is fixed from the bottom. In the right side of the tank electric motor drivenpump is fitted on four studs with suction and delivery value nearly arrangement is available for tightening and losing the valve. When the return is closed and delivered by the pump is to cylinder by flow control volume.

Upper and lower push is available on the switches at the control panel a switch is useful for upward and downward movement of the movable head. The ON and OFF switches are also available the piston pump has the transmission of main supply.

19 Switch Adjustment

The tonnage of load of the specimen is fixed according to the weight.

20 Tensile Test

Select the job and adjust upper and lower check adjustment. Then operate the upper end of the specimen is tightened by upper cross head grip. The keep the lower left valve is close is close position. Then open right valve and close it after lower table is lightly lifted.

Then set the lower points to zero by mean of adjusting knob. This is used to move the dead weight of lower table. The locking is done by operating job working handle.

After open left control volume when the specimen breaks it is known as breaking load.Ultimate load is maximum load.

21 Stress – Strain Graph

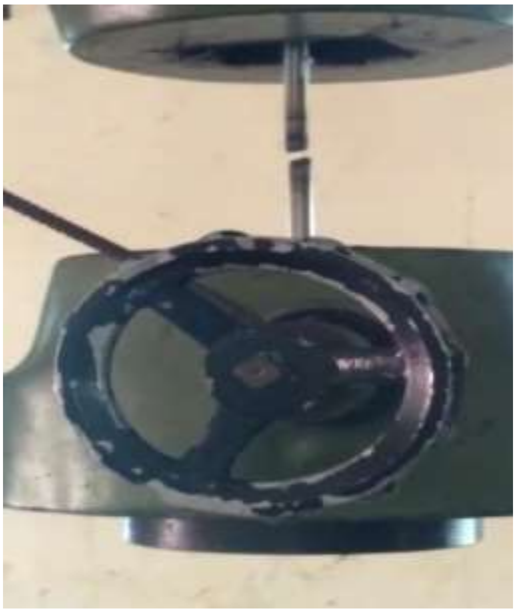

Figure 5 After Breakage of specimen

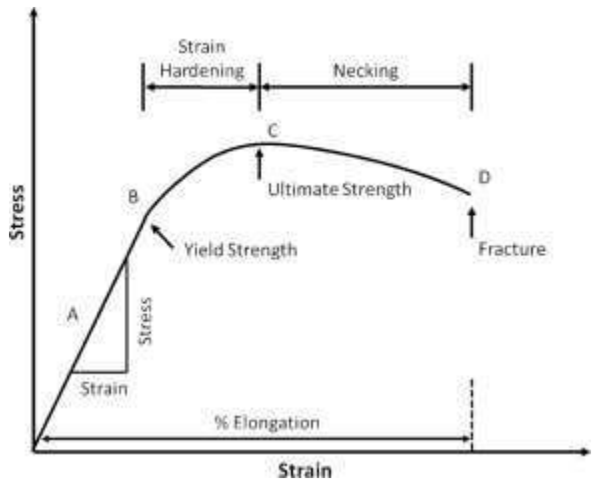

Figure 6 Stress Strain curve

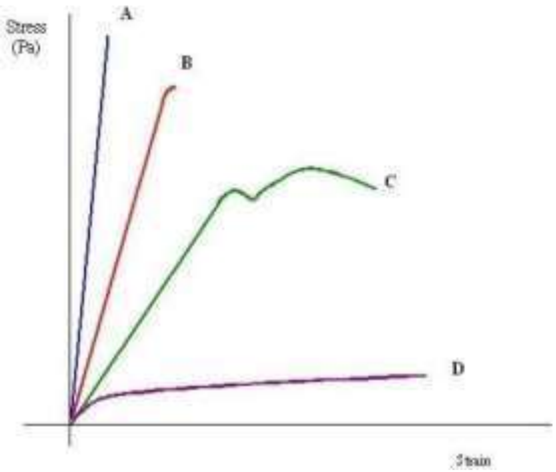

Figure 7 Stress - Strain graphs of different materials

Curve A denote brittle material. It is strong because it has little strain for long stress. Curve B shows stress material which is not ductile. Curve C is ductile. Curve D is plastic material.

22 Ultimate Tensile Stress

$$\text{Upper tensile stress} = \frac{\text{Ultimate strength}}{\text{Area}}$$

23 Methodology

Experimental Setup

The workpiece is SS202 of diameter 304.8 mm length 12 mm argon is used as shielding gas. The specimen welded by MIG welding as per the standard of ASTM A 276.

Element	C	Cr	Ni	P	Mn	Si
Composition %	0.12	18	4	0.06	7.5	0.9

Table 1 Composition of SS 202

Stainless Steel Properties

Property	Value (S.I)	Units (S.I)
Tensile Strength	515	MPa
Yield Strength	275	MPa
Elastic Modulus	201	GPa
Poisson's ratio	0.27-0.30	-
Elongation at Break	40	%

Table 2 SS 202 Properties

Procedure

The three parameter such as gas flow rate, current and filler rod diameter are important one.
Initial setup,
Current = 140 amp, Gas flow rate = 6 lit/min. and Voltage = 24 V
The workpiece is welded and then tested in UTM.
First workpiece,
Current = 140 amp, Gas flow rate = 10 lit/min. and Voltage = 26 V
Then the workpiece welded and tested. Then again,
Current = 150 amp, Gas flow rate = 8 lit/min. and Voltage = 25 V
Then welded and tested. Then again,
Current = 150 amp, Gas flow rate = 10 lit/min. and Voltage = 26 V
Then the workpiece is welded and tested. Then again,
Current = 160 amp, Gas flow rate = 6 lit/min. and Voltage = 24 V
Then the workpiece id welded and tested. Finally ultimate tensile strength is plotted in a table.

Calculation

Diameter, D = 12 mm and Length, L = 302. 4 mm

Area $= \Pi/4\ D^2$

$= \Pi/4\ 12^2 = 113.09$ mm

Welded joint 1

Ultimate tensile strength $=$ (Ultimate strength)/Area $= 37 \times 10^3 / 113.09$

$= 309.04$ N/mm^2

Welded joint 2

Ultimate tensile strength $= 44\times10^3 / 13.09$

$= 389.04$ N/mm^2

Welded joint 3

Ultimate tensile strength $= 38\times10^3 / 13.09$

= 309.48 N/mm^2

Welded joint 4

Ultimate tensile strength = 38×10^3 / 13.09

= 336.01 N/mm^2

Welded joint 5

Ultimate tensile strength = 42×10^3 / 13.09

= 371.38 N/mm^2

Welded joint 6

Ultimate tensile strength = 41×10^3 / 13.09

= 362.54 N/mm^2

Welded joint 7

Ultimate tensile strength = 52×10^3 / 13.09

= 459.81 N/mm^2

Welded joint 8

Ultimate tensile strength = 40.5×10^3 / 13.09

= 358.12 N/mm^2

Welded joint 9

Ultimate tensile strength = 40×10^3 / 13.09

= 352.70 N/mm^2

Calculation of S/N ratio

$$SN_L = -10 \log[\frac{1}{n} \sum_{n=0}^{i} \frac{1}{yi^2}]$$

We know S/N ratio for larger is better,

For first run:

If n =1

Welded joint 1

$SN_L = -10 \log [\frac{1}{327.15}]$ = 50.29 dB

Welded joint 2

$SN_L = -10 \log [\frac{1}{389.04}]$ = 51.79 dB

Welded joint 3

$SN_L = -10 \log [\frac{1}{309.48}]$ = 49.81 dB

Welded joint 4

$$SN_L = -10 \log [\frac{1}{336.01}] \qquad = 50.52 \text{ dB}$$

Welded joint 5

$$SN_L = -10 \log [\frac{1}{371.38}] \qquad = 50.39 \text{ dB}$$

Welded joint 6

$$SN_L = -10 \log [\frac{1}{362.54}] \qquad = 51.18 \text{ dB}$$

Welded joint 7

$$SN_L = -10 \log [\frac{1}{459.81}] \qquad = 53.25 \text{ dB}$$

Welded joint 8

$$SN_L = -10 \log [\frac{1}{358.12}] \qquad = 51.08 \text{ dB}$$

Welded joint 9

$$SN_L = -10 \log [\frac{1}{358.12}] \qquad = 50.98 \text{ dB}$$

Result and Discussion

Sl. No	**Current (A)**	**Voltage (v)**	**Gas flow rate (lit/min)**	**Ultimate tensile strength (MPa)**	**S/N ratio (dB)**
1	140	24	6	327.15	50.29
2	140	25	8	389.04	51.79
3	140	26	10	309.48	49.81
4	140	24	8	336.01	50.52
5	140	25	10	371.38	51.39
6	140	26	6	362.54	51.18
7	140	24	10	459.81	53.25
8	140	25	6	358.12	51.08
9	140	26	8	353.70	50.97

Table 3 Result tabulations

Here the array specifies nine experimental runs and has 3 columns.

Graph

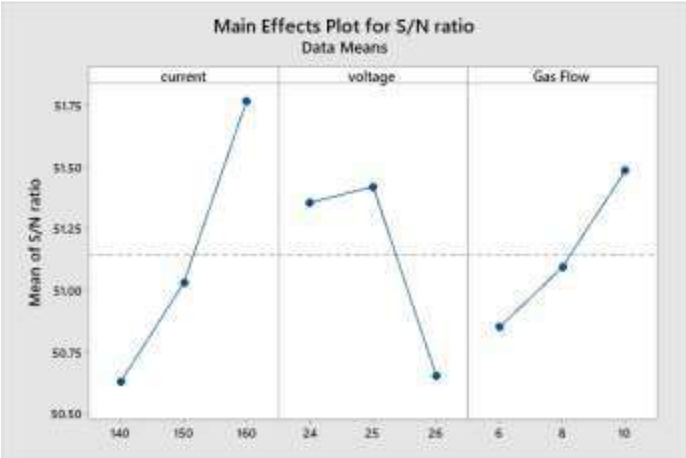

Figure 8 Mean of S/N Ratio

Level	Current	Voltage	Gas flow rate
1	50.63	51.35	50.85
2	51.03	**51.42**	51.09
3	**51.76**	50.65	**51.48**
Delta	1.13	0.77	0.63
Rank	1	2	31

Table 4

24 Conclusion

Tensile strength of SS has been evaluated under different processing condition using 3^3 full factorial experimental data applying Taguchi methodology. Initially L9 array is taken into account and put S/N ratio.

A Maximum tensile strength is found out as,

Current = 160 amp, Gas flow rate = 10 lit/min and Voltage = 25V

25 Application of Stainless Steel

1. SS is mainly used in kitchen accessories, cutlery and cookware, sinks, grills and saucepans.
2. It is mainly used in modern construction and exterior cladding for high impact buildings, counter top and backsplashes.
3. Surgical implants and replacement joints such as artificial hips. SS pins and plates areused to fix broken bones.

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