A REVIEW PAPER ON GAS METAL ARC WELDING (GMAW) OF MILD STEEL 1018 BY USING TAGUCHI TECHNIQUE

Monika[1], Jagdip Chauhan[2]
[1,2]Department of Mechanical Engineering
Guru Jambheshwar University of science and Technology Hisar, India.

Abstract

MS-1018 is non-hardenable ductile steel belonging to low carbon steel categories. It has been widely used for machining applications like machine parts, rod, bolts, studs etc. It shows that good weld ability and also used for carburized parts. The present review paper study the effect of different process parameters such as welding current, voltage, gas flow rate, welding speed and gas pressure on mechanical properties like tensile strength and percentage of elongation of GMAW welded joints of MS 1018 plates. GMAW welding is a high deposition rate welding process in which wire is continuous feed from a gun or spool. GMAW welding offers several advantages like all position capable, long weld can be made, no slag etc.

Optimization was done to find optimum welding conditions to maximize tensile strength and percentage elongation of welded joints. The confirmation test was also conducted to validate the optimum parameters settings. From the review papers study, it is found that when the welding current, voltage, GFR increased, the tensile strength decreases, but when welding speed increases, the tensile strength also increases.

Index Terms: MS-1018, Tensile strength, Percentage of elongation, Taguchi Technique, Current, voltage, Gas Flow Rate.

I. INTRODUCTION

Welding is a process of joining two similar and non-similar metal or non-metal with the application of heat and pressure, but in some cases without the application of pressure the process have been done. The filler wire is used to join the metal in GMAW process with the help of spool gun. Welding is used for making permanent joints. It is used for the manufacturing of automobile parts, railway wagons, aircraft frames, machine parts, tanks, structural works, boilers, ship building furniture etc.

Gas Metal Arc Welding (GMAW) is an arc welding process which produces the coalescence of metals by heating them with an arc between a continuously fed filler metal electrode and the work. The arc and the weld pool are shielded from atmospheric contamination by passing a suitable gas through the nozzle to form a protective shield around the welding area.

1.1 Process Parameters:

- Electrode Size
- Welding Current
- Welding Voltage
- Arc Travel Speed
- Electrode Extension
- Electrode Position
- Gas Flow Rate and Types of shielding gases

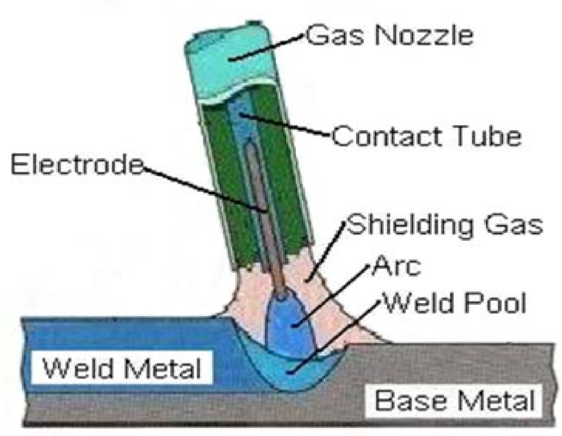

Figure 1.1: Gas Metal Arc Welding Process [1]

1.2 Types of Welding Joint

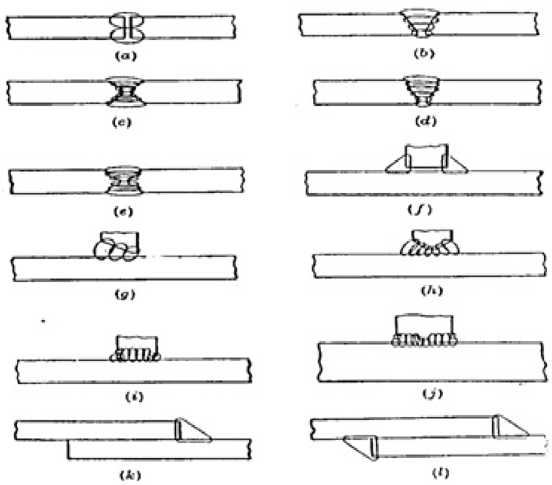

Figure.1.2: Types of welding joints [2]
(a) square butt joint; (b) single-v butt joint; (c) double-v butt joint; (d) single-u butt joint;(e) double-u butt joint; (f) square-t joint; (g) single-bevel t-joint; (h) double-bevel t-joint;(i) single-u t-joint; (j) double-u t-joint; (k) single-bead lap joint; (l) double-bead lap joint.

1.3 The Chemical Composition of MS 1018

Sr. No.	Element	Content
1.	Carbon, C	0.14 - 0.20 %
2.	Iron, Fe	98.81 - 99.26 %
3.	Manganese, Mn	0.60 - 0.90 %
4.	Phosphorous, P	≤ 0.040 %
5.	Sulphur, S	≤ 0.050 %

1.4 Advantages of GMAW

The advantages of GMAW welding are as follows:

- This method is financially attractive due to a high welding speed and because a long arc time can be maintained as there is no frequent changing of electrode rods.
- This method gives the opportunity for rational welding of materials which are difficult to weld.
- Welding is possible in all positions.
- The arc and the weld pool are clearly visible.
- Only used little after treatment of the weld is necessary.

1.5 Disadvantages of GMAW

Some of the disadvantages of GMAW welding are as follows:

- There is a risk of serious welding errors such as lack of fusion, etc. if the welder is not sufficiently skilled with a profound knowledge of the process and its welding parameters.
- The necessary, but costly, shielding of the welding place at outdoor jobs.
- Greater investments in welding equipment and expenses to maintenance to the welding equipment.

1.6 Applications of GMAW

- GMAW is usually used with Aluminium, ordinary mild steels, Stainless steels, Copper and copper alloys.
- In addition to the above metals this method is suitable for magnesium, nickel and a number of other metals and their alloys.
- It has been used successfully in industries like aircraft, automobile and ship building.
- It gives high surface hardness and a soft core to parts that include studs, worms, ratchets, dogs, chain needles, pins, liners, machinery frames, special bolts, oil tool slips, tie rods, anchor pins, etc.

1.7 Mechanical Properties of MS- 1018

Sr. No.	Mechanical Properties	Range
1.	Brinell Hardness	126
2.	Knoop Hardness	145
3.	Rockwell Hardness	71
4.	Vickers Hardness	131
5.	Tensile Strength, Ultimate	440 MPa
6.	Tensile Strength, Yield	370 MPa
7.	Elongation	15.0%
8.	Reduction of area	40.0%
9.	Modulus of Elasticity	205 GPa
10.	Bulk Modulus	140 GPa
11.	Poissons Ratio	0.290
12.	Machinability	70%
13.	Shear Modulus	80 GPa

II. LITERATURE REVIEW

1. **Ghosh et al. (2016**) reviewed that the plate of 3mm thickness is used for preparing the welding butt joint. The X ray test result shows that lack of penetration and visual inspection indicate the undercut spatter and blow holes in some sample. The optimum parameters founded by taguchi

method are current 10A,gas flow rate 20l/min and nozzle distance 15mm and current is more significant as compared to gas flow rate and nozzle distance.[3]

2. **Prakash et al. (2016)** the present work deals with optimization of welding process variables by using MIG welding. In this process input variables are arc voltage (V), current (A) and welding speed(S) with tensile properties, hardness &penetration as responses of low carbon steel (ASTM A29). Design of experiments based on taguchi orthogonal array [L9]; and analysis of variance (ANOVA) is used to determine the impact of parameters with the optimal condition [4].

3. **Singhmar et al. (2015**) reviwed that the various combination of parameters were obtained by conducting the experiment as per the orthogonal array. Arc current has the highest influence on the tensile strength with contribution of 41%followed by Arc voltage with contribution of 20% and gas flow rate with contribution of 16%.[5]

4. **Kalita et al. (2015)** In the present work the effect of three important parameters of MIG welding ;welding voltage, current and shielding gas flow rate on the tensile strength of C20 steel has been studied. An experiment has been designed using Taguchi's L9 orthogonal Array with three repetitions. All welding work has been carried out using ER70S-4 electrodes. Results shows that welding voltage has significant effect, both on mean and variation of the tensile strength of the weld having 87.019% and 85.398% contribution respectively, whereas welding current has significant effect on mean only (10.807% contribution).Shielding gas flow rate has insignificant effect on the tensile strength of weld. From analysis of experimental data the optimal setting is found to be: Welding current 200 amp. Welding voltage 30V and Shielding gas flow rate (CO2) 8lit/min. we can use other variable parameters also like electrode size, root gap, plate thickness &welding speed etc. with other materials combinations [6].

5. **Patil et al. (2014**) reviewed that the among main input welding parameters the effect of the welding speed is significant. If increasing the welding speed and decreasing the current influences also increase the ultimate tensile strength of welded joint. In this research work done it was observed that the voltage did not contribute such as to weld strength .Regardless of the set of the quality characteristic, greater S/N ratio relates to better the quality characteristics [7].

6**. Kumar et al. (2013)** this paper shows that the result of the analysis of variance (ANOVA) for the Hardness (BM, WZ, HAZ).The analysis of variance was carried out at 95% confidence level. The ANOVA is carried out to investigate the influence of the design parameters on hardness by indicating that which parameter is significantly affected the quality characteristics. In this experimentation work, the authors have generated results for S/N ratios of Hardness (BM, WZ, and HAZ) [8].

7. **Anoop c a et al. (2013)** The reviewed study has discussed an application of the Taguchi method for investigating the effects of process parameters on the weld microhardness; grain size and HAZ width in the GTA Welded aluminium alloy of 7039. From the analysis of the results using the S/N ratio approach, analysis of variance and taguchi's optimization method, the following can be concluded: Peak current of 150 A ,base current of 75A and pulse frequency of 150Hz are the optimized welding parameters for getting highest micro hardness, smallest eqiuxed weld grains and minimum HAZ width. Out of three selected parameters, peak current has the highest contribution i.e. 61.58% [9].

8. **Chhabra et al. (2013)** in this study, the process parameters are optimized by using the taguchi's techniques based on taguchi's L9 orthogonal array. Experiments have been conducted based on three process parameters, namely the three shielding gases, welding current and arc travel speed and three levels of each parameters were carefully selected. Micro hardness has been predicted for the optimum welding parameters and parameters percentage of contribution in producing a better joint is calculated, by applying the effect of the S/N ratio and analysis of variance .Based on the study, shielding gas was found to be the most significant variable over the other process parameters while the welding current and arc travel speed took the second and third rank respectively. The optimum parameters for the high micro hardness obtained through the taguchi is the combination of process parameters of Ar+CO2 shielding gas, 190 Amp. welding current and 22 cm/min arc travel speed. Maximum hardness, in terms of optimum value of 432 HV is achieved. Shielding gas (Ar+CO2) was most significant with 68.36% contribution,

followed by the welding current or 16.30% and arc travel speed of 12.88%.[10]

9. **Patil and Waghmare et al. (2013)** evaluated the process parameters of welding current, welding voltage, welding speed to investigate their influence on ultimate tensile strength (UTS) for MIG welded specimen of mild steel by using Taguchi's method. They concluded that the welding speed was most influencing parameter with 88.20% contribution followed by current of 10.76% and voltage of 0.69%.[11]

10. **Kurt and Samur et al. (2013)** studied the mechanical properties of 304 stainless steels jointed by tungsten inert gas welding by using 308 stainless steel filler wire. They concluded that the hardness value of welding zone was less than parent metal and higher than heat affected zone. The tensile strength, yield strength and elongation were found to be 1800MPa, 75MPa and 25% respectively. It was also concluded that the ductile fracture was carried out in heat affected zone [12].

11. **Patel and Chaudhary et al.(2013**) evaluated the parameters considered wire diameter, welding current, and wire feed rate to investigate their affect on weld bead hardness for MIG welding and TIG welding by Grey Relational Analysis (GRA). From the study it was concluded that the welding current was most significant parameter for MIG welding and TIG welding. By the use of grey relational analysis optimization technique, the optimal process parameter combination was found to be welding current 100 Amp, wire diameter 1.2 mm and wire feed rate 3 m/min for MIG welding and welding current 80 Amp and wire diameter 0.8 mm for TIG welding.[13]

12. **P. K. Palani et al. (2013)** Tungsten inert gas welding is one of the widely used techniques for joining ferrous and non-ferrous metals. Tungsten inert gas welding offers several advantages like the joining of dissimilar metals, low heat affected zone, less of slag etc. The aim of this paper is to investigate the influence of Tungsten inert gas welding process parameters on welding of Aluminium-65032. Response Surface Methodology was used to control the experiments. The input parameters selected for controlling the process are welding current, speed and gas flow rate. Strength of welded joint was tested by a UTM. The Percentage of elongation was also calculated to check the ductility of the welded joint. From the results we found that the mathematical models have been developed to study the effect of process parameters on tensile strength and percentage of elongation. The Optimization and Confirmation, tests were used to find out the optimal welding conditions to validate the optimum parameter settings [14].

13. **Rao and Padmanabhan et al. (2012)** evaluated the process parameters considered were voltage, feed rate and electrolyte concentration to investigate their influence on metal removal rate in electro chemical machining of Al/5%SiC composites by Taguchi's method. From the study it was concluded that feed rate was most significant parameter with 58.09% contribution followed by voltage of 16.30% and electrolyte concentration of 7.57%. The optimum parameters for high metal removal rate were found to be voltage 20V, feed rate 0.3 mm/rev and electrolyte concentration 30 lit/min [15].

14. **Chomsamutr and Jongprasithporn et al. (2012**) used Taguchi's approach and Response Surface Methodology to design process parameters of MIG welding that optimize tool life of welded joints for mild steel. The process parameters considered were depth of cut, cutting speed and feed rate.L9 orthogonal array was used for designing experiments. It was concluded from the work that the longest tool life found by Taguchi's approach was 670.170 min and by Response Surface Methodology it was found to be 670.230 min. The optimum parameters were found to be depth of cut 0.5 mm, cutting speed 150m/min and feed rate 0.10 mm/rev [16].

15. **Sapakal and Telsang et al. (2012)** evaluated the parameters; current, voltage and welding speed to investigate their influence on depth of penetration of MS material by Taguchi's design. It was concluded from the study that voltage was most influencing parameter with percentage contribution of 84.42 followed by welding speed with 6.83% and current with 3.55%.[17]

16. **Aghakhani et al. (2011)** used Taguchi's method to design process parameters of GMAW that optimize weld dilution for welded joints. The process parameters considered were feed rate, welding voltage, arc gap, welding speed and gas flow rate. L25 orthogonal array was used for designing experiments. From the study it was concluded that wire feed rate was most significant parameter and gas flow rate was least significant parameter for weld dilution [18].

17. **Haragopal et al. (2011)** used Taguchi's method to design process parameters of MIG welding that optimize mechanical properties of

weld specimen for aluminium alloy (Al-65032). The process parameters considered were gas pressure, current, groove angle and pre-heat. L9 orthogonal array was used for designing experiments. It was concluded from the work that current was most influencing parameter for ultimate tensile strength (UTS) and pressure was most influencing parameter for proof stress, %age elongation and impact energy [19].

III. CONCLUSION

From the review paper study, it is found that when the welding current ,voltage ,GFR increases ,The tensile strength decreases ,but when welding speed increases ,the tensile strength also increases. In the case of elongation is also same to tensile strength.

Optimization was done to find optimum welding conditions to maximize tensile strength and percentage of elongation of welded joints. This study presented the optimization of GMAW parameters of Mild Steel 1018 by Taguchi's experimental design. The process was applied using a specific set of controllable parameters Voltage, Current, Gas Flow Rate for the response variables of Tensile Strength. L9 orthogonal array, S/N ratio analysis of variance were used for this study. The Study found that the control factors had varying effects on the response variables.

IV. REFERENCES

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