International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Optimization of MIG Welding Process Parameters – Experimental Study

Sopan Shelar[a*], Prof P. B. Dengale[b]

[a] PG Student, Department of Mechanical Engineering, Sahyadri Valley College of Engineering, Rajuri, India.
[a] Assistant Professor, Department of Mechanical Engineering, Sahyadri Valley College of Engineering, Rajuri, India.

ABSTRACT :

Welding process parameters can plays a very significant role in determining the quality of the welded joint in metal inert gas (MIG) welding operation. The elaborated experiments and analysis have been needed to precise control of the MIG welding process to obtain the desired quality characteristics in welded specimens. In this work to study and analyze the effects of welding parameters: welding current, welding voltage and Gas flow rate on ultimate tensile strength (UTS) in MIG welding of Mild steel materials.

Keywords: Welding, MIG, UTS, Mild Steel

Introduction :

Welding is a quick and cost-effective process to join two materials permanently. It provides flexibility in design and simplifies the construction of large structures. It plays a key role in metal fabrication industry. Today, virtually all the metal products are welded. Products like jet engines, pipelines, automobiles, building construction, airplanes etc. could not have materialized without welding. Mild steel is the most common form of steel frequently used in industries and construction works as it is cheaper and has properties which are suitable for various applications. Mild steel has excellent weldability. It goes into most of the structures fabricated by welding such as bridges, ships, tanks, pipes, buildings, railroad cars and automobiles. Mild steels are produced in greater quantities than all other steels combined and they make up the largest part of welded fabrication. Due to large scale use of steel structures, manufacturing costs and efficiency have become prime factors for further development. Conventional welding processes need to be more flexible and smarter to have better adaptability and higher efficiency. This is necessary for the industries to remain globally competitive in the today's dynamic world. Metal Inert Gas (MIG) commonly known as Gas Metal Arc Welding (GMAW) was devised during the Second World War. The technique generates an electric arc between a consumable wire electrode and the workpiece metal to obtain coalescence. The MIG welding has gained traction in its use due to its relatively low cost and increased productivity, ease of multidimensional welding, non-skill intensive, robustness in its application to many metallic materials (ferrous and nonferrous).

Nomenclature

Aradius of
Bposition of
Cfurther nomenclature continues down the page inside the text box

In MIG welding process, several factors culminate into the quality of the welds. These factors include the metallurgical properties, bead geometry, and the weld chemistry are of significant influence. [10]

Kapil B. Pipavat et al. (2014), studied Optimization of MIG welding Process Parameter using Taguchi Techniques. This paper presents the influence of welding parameters like welding current, welding voltage, welding speed etc. on mechanical properties like tensile strength, hardness etc. on austenitic stainless steel AISI 316. By using DOE method, the parameters can be optimize and having the best parameters combination for target quality. The analysis from DOE method can give the significance of the parameters as it give effect to change of the quality and strength of product or does not. A plan of experiments based on Taguchi technique has been used to acquire the data. An Orthogonal array and analysis of variance (ANOVA) are employed to investigate the welding characteristics of austenitic stainless steel AISI 316 material and optimize the welding parameters. The techniques used for obtaining optimal process parameters with the use of experimental data have been reviewed. The success of MIG welding process in terms of providing weld joints of good quality and high strength depends on the process conditions used in the setup. This research aims to identifying the main factors that have significant effect on weld joint strength. [1]

- **Nabendu Ghosh et al. (2016)**, Investigated Parametric Optimization of MIG Welding on 316L Austenitic Stainless Steel by Grey-Based Taguchi Method. In the present work, visual inspection and X-ray radiographic test has been conducted in order to detect surface and sub-surface defects of weld specimens made of AISI 316L austenitic stainless steels. Effect of current, gas flow rate and nozzle to plate distance on quality of weld in metal inter gas arc welding of AISI 316L has been studied in the present work through experiments and analyses. Butt welded joints have been made by using several levels of current, gas flow rate and nozzle to plate distance. The quality of the weld has been evaluated in terms of yield strength, ultimate tensile strength and percentage of elongation of the welded specimens. The observed data have been interpreted, discussed and analyzed by using Grey - Taguchi methodology. [2, 3]
- **Saadat Ali Rizvi et al.**, investigated Optimization of Welding Parameters by Using Taguchi Method and Study of Fracture Mode Characterization of SS304H Welded by GMA Welding. This study focuses on optimizing different welding parameters which affect the mechanical properties such as YS, UTS, Toughness, and Vicker hardness (VHN) of SS304H, Taguchi technique was employed to optimize the welding parameters, and fracture mode characterization was studied. A series of experiments have been carried out. L9 orthogonal array (3x3) applied for it. Statistical methods of signal to a noise ratio (SNR) and the analysis of variance (ANOVA) was applied to determine the effects of different welding parameters such as wire feed speed, welding current and gas flow rate on Mechanical properties. Tensile strength, toughness, Vicker hardness (VHN), and mode of fracture were examined to investigate the weld quality of SS304H, and it was observed from the results that the welding voltage has significant effect whereas gas flow rate has insignificant effect on tensile strength of the weldment, and optimum process parameters were found to be 23 V, 350 IPM travel speed of wire and 20 l/min gas flow rate for tensile strength and mode of fracture was ductile fracture for tensile test specimen. [6]
- **Dr. P. Vijayavel et al. (2018)**, studied Optimization of MIG Welding Parameters For Improving Strength of Welded Joints. In this work, the influence of welding parameters like welding current, welding voltage, welding speed on ultimate tensile strength (UTS) of AISI 1050 mild steel material during welding. A plan of experiments based on Taguchi technique has been used. An Orthogonal array, signal to noise (S/N) ratio and analysis of variance (ANOVA) are employed to study the welding characteristics of material & optimize the welding parameters. The result computed is in form of contribution from each parameter, through which optimal parameters are identified for maximum tensile strength. From this study, it is observed that welding current and welding speed are major parameters which influence on the tensile strength of welded joint. [7]

  From literature review it is clearly observed that very less work had been carried out on the Influence MIG welding process parameters (welding current, welding voltage and Gas flow rate) on tensile strength of Mild steel materials. It is also observed that there is chance to find out an optimal setting of input parameters in MIG welding process. Literature shows that more practical options are available to improve the strength of welding in MIG welding process using taguchi method. This optimization technique of parameters is also prevent engineer or production controller from doing something that waste in production such as time and produce a better product.

1. Aspects of MIG Welding Process

The process is a common, versatile welding process. It provides high deposition rates and is suited to a wide range of material thicknesses, thin too thick. Compared with Manual Arc welding the process provides a weld with minimal weld finishing as there is minimal spatter and no electrode slag. It requires a low – medium skill level and has less problems to achieve good quality compared to TIG/MMA it has a narrow heat affected area. Its disadvantage is the torch is subject to a number of wear components such as contact tips, nozzles, liners etc. It is often a process that is automated to provide even higher production rate.

Gas metal arc welding (GMAW), sometimes referred to by its subtypes metal inert gas (MIG) and metal active gas (MAG) is a welding process in which an electric arc forms between a consumable MIG wire electrode and the workpiece metals, which heats the workpiece metals, causing them to fuse (melt and join). Along with the wire electrode, a shielding gas feeds through the welding gun, which shields the process from atmospheric contamination. The process can be semi-automatic or automatic. A constant voltage, direct current power source is most commonly used with GMAW, but constant current systems, as well as alternating current, can be used. There are four primary methods of metal transfer in GMAW, called globular, short-circuiting, spray, and pulsed-spray, each of which has distinct properties and corresponding advantages and limitations.

Originally developed in the 1940s for welding aluminium and other non-ferrous materials, GMAW was soon applied to steels because it provided faster welding time compared to other welding processes. Today, GMAW is the most common industrial welding process, preferred for its versatility, speed and the relative ease of adapting the process to robotic automation. Unlike welding processes that do not employ a shielding gas, such as shielded metal arc welding, it is rarely used outdoors or in other areas of moving air. A related process, flux cored arc welding, often does not use a shielding gas, but instead employs an electrode wire that is hollow and filled with flux.

Fig. 1 - (a) MIG Welding Process

2. Experimentation

2.1. Design of Experiment

Dr. Genichi Taguchi is regarded as the foremost proponent of robust parameter design, which is an engineering method for product or process design that focuses on minimizing variation and/or sensitivity to noise. When used properly, Taguchi designs provide a powerful and efficient method for designing products that operate consistently and optimally over a variety of conditions. Minitab is a statistical tool used for analysis and interpretation of experimental data. In industry designed experiments can be used to systematically investigate the process or product variables that influence product quality. After you identify the process conditions and product components that influence product quality, you can direct improvement efforts to enhance a product's manufacturability, reliability, quality, and field performance.

2.2. No of Experiment

Number of Experiments to is decided with the help of Taguchi Method using Minitab-16 Software. Three factors (Welding current, welding voltage and Gas flow rate) at 3 levels each are as follows:

Table 1 –MIG Experimental Parameters

Control Factors	Level		
	I	II	III
Current (Amp)	120	140	160
Voltage (V)	20	25	30
Gas Flow Rate (l/min)	14	16	18

2.3. Work piece Material

The material is used in this work is Mild steel for MIG welding process. The nominal compositions of the material are shown in Table 2.

Table 2 –MS Material Properties

Content	C	Si	Mn	P	Fe
Percentage	0.17	0.20	0.54	0.16	Balance

Fig. 2 - Specimen Material – MS.

2.4. Experimental Setup

MIG welding is carried out on Mild steel specimens using ESAB AUTO K 400 MIG welding machine. Fig. 3 shows the welding machine and Table 3 shows its technical specifications.

Fig. 3 – MIG Welding Setup

Table 3 –Specifications of MIG Welding Machine.

Specification	Value
Model	ESAB AUTO K 400
Dimensions (l×w×h)	675 mm×350 mm×690 mm
Weight	122 KG
Technology	Thyristor based
Automatic Grade	Semi-automatic
Input Voltage	Frequency - 50 Hz Phase - 3 Voltage - 415 V
Current Range	60 - 400 A
Open Circuit Voltage	55 V
Application Classification	S
Welding Output at i. 60% duty cycle ii. 100% duty cycle	 400A 310A

3. Result and Discussions

Transverse tensile specimens with as per ASTM standard were prepared. At Room- temperature tensile tests were conducted on welded samples as per ASTM on a universal tensile testing machine. Fig. 4 shows the dimension of welded workpiece as per ASTM Standards.

Fig. 4 – Tensile Specimen

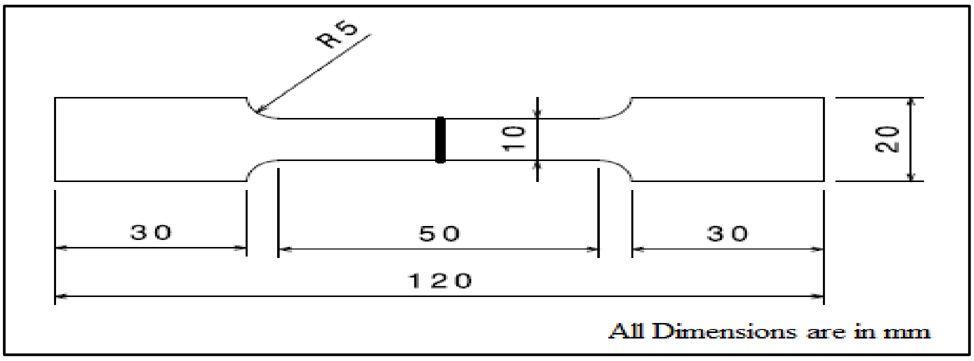

Fig. 5 – Tensile Test Job.

Table 5 - Experimental Result of Tensile strength

Run	Welding current (A)	Welding Voltage (V)	Gas Flow Rate (L/min)	Tensile strength (Mpa)
1	120	20	14	378.12
2	120	25	16	361.02
3	120	30	18	365.36
4	140	20	16	341.21
5	140	25	18	330.89
6	140	30	14	360.18
7	160	20	18	329.32
8	160	25	14	339.21
9	160	30	16	325.11

4. Conclusion

In this study, the experiments are conducted to obtain optimal condition for MIG Welding of Mild steel material. Experimental results were evaluated and following conclusions are drawn:

- From experimentation it was observed that the optimum levels of process parameters in MIG Welding. The optimum level obtained at welding current, welding voltage & gas flow rate of 120 A, 30 V & 14 L/min respectively.
- In this investigation Welding current plays a vital role.
- In this investigation Gas flow rate is second most influencing parameter.
- Welding current has negligible influence on Tensile strength

REFERENCES :

1. Kapil B. Pipavat, Dr. Divyang Pandya, Mr. Vivek Patel, Optimization of MIG welding Process Parameter using Taguchi Techniques, International Journal of Advance Engineer ing and Research Development (IJAERD) Volume 1,Issue 5,May 2014.
2. Nabendu Ghosh, Pradip Kumar Pal, Goutam Nandi, Parametric Optimization of MIG Welding on 316L Austenitic Stainless Steel by Grey-Based Taguchi Method, Procedia Technology 25 (2016) 1038 – 1048.
3. Nabendu Ghosh, Ramesh Rudrapati, Pradip Kumar Pal, Gotam Nandi, Parametric Optimization of Gas Metal Arc Welding Process by using Taguchi method on Ferritic Stainless Steel AISI409, Materials Today: Proceedings 4 (2017) 2213– 2221.
4. Arunkumar Sivaramana, SathiyaPaulraj, Multi-Response Optimization of Process Parameters for MIG Welding of AA2219-T87 by Taguchi Grey Relational Analysis, Materials Today: Proceedings 4 (2017) 8892–8900.
5. Balaram Naik, A. Chennakeshava Reddy, Optimization of Tensile Strength in TIG Welding Using Taguchi Method and Analysis of Variance (ANOVA), Thermal Science and Engineering Progress (2018).
6. Saadat Ali Rizvi, S.P Tewari, Optimization of Welding Parameters by Using Taguchi Method and Study of Fracture Mode Characterization of SS304H Welded by GMA Welding, Jordan Journal of Mechanical and Industrial Engineering, Volume 12 Number 1, June. 2018.
7. Dr. P. Vijayavel, Dr. G. Mahesh, Mr. M. Venkatswamy, Mr. C. Shashikanth, Optimization of MIG Welding Parameters For Improving Strength of Welded Joints, International Journal of Current Engineering and Scientific Research (Ijcesr), Volume-5, Issue-1, 2018.
8. S. Kumar, R. Singh, Optimization of Process Parameters of Metal Inert Gas Welding with Preheating on AISI 1018 Mild Steel using grey based Taguchi Method, Measurement (2019).
9. G. Shanmugasundara*, B. Karthikeyanb , P. Santhosh Ponvellc, V. Vigneshd, Optimization of Process Parameters in TIG Welded Joints of AISI 304L - Austenitic Stainless Steel using Taguchi's Experimental Design Method, Materials Today: Proceedings 16 (2019) 1188–1195.
10. Pardon Baloyi, Stephen A. Akinlabi, Nkosinathi Madushele, Paul A. Adedeji, Sunir Hassan, Zwelinzima Mkoko, Esther T. Akinlabi, Two-staged technique for determining ultimate tensile strength in MIG welding of mild steel, Materials Today: Proceedings 44 (2021) 1227–1234.