Optimization of MIG welding parameters through Tagauchi optimization process

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Abstract- Manufacturer face the problem of control the process input parameters to obtain a good welded joint with the required weld quality. Traditionally, it has been necessary to study the weld input parameters for welded product to obtain a welded joint with the required quality. It requires a time-consuming trial and error development method. The purpose of this study is to propose a method to decide optimal settings of the welding process parameters in MIG welding. Properties include Tensile strength, Impact strength, Hardness, etc. also influenced process parameters. The MIG welding parameters are the most important factors affecting the quality, productivity and cost of welding. This paper presents the influence of welding parameters like welding current, welding voltage, welding speed etc. on mechanical properties like tensile strength, hardness etc. 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.

Keywords- MIG welding, MIG welding setup, Titanium alloy, Taguchi.

1. Introduction

MIG welding (also known as metal inert gas), also known as MAG (Metal Active Gas) and in the USA as GMAW (Gas Metal Arc Welding), is a welding process now widely used in welding a variety of ferrous and non-ferrous materials. The main characteristic of this process is the small electrode wire, which is continuously fed into the arc of the coil. As a result, this process can produce fast and elegant welding on a wide range of joints.

MIG welding is performed on the positive electrode (wire) (DCEP). However, DCEN is used with some self-protecting and gas-protected cores (for high combustion rates). The direct current power supply unit is designed with transformer rectifier and has flat property (constant voltage power supply). The most common type of power supply used in this process is the primary transformer rectifier with constant-voltage characteristics, which comes from three-phase inputs 415V and 240V single-phase. The AC output of the three-phase motor after the whole wave correction is very smooth. In order to obtain a smooth output after correcting the whole wave with a single-phase motor, it is necessary to install a large capacitor bank at both ends of the output. Due to the cost of doing so, many low-cost single-phase motors ignore this part, providing weak welding properties. The main transformer winding switch provides the output voltage step in the power output terminal. Another way to generate different volts on the terminals of the power output is to use a thyristor or transistor rectifier instead of a simple diode rectifier. The system provides a continuously variable output voltage, which is especially useful in mechanical installations, and the cost of this rate can be partially offset without the need for a voltage switch or a winding of the primary winding of the transformer.

Most MIG power supplies have circuit breakers or relay to turn on / off the output by operating the actuator on the MIG igniter. The process of closing the conductor is usually delayed so that the wire is burned from the welding pool. The thermostat is installed at the highest position in the power supply and connected in series with a coil cutter to provide thermal protection for the device. The performance of the power supply is measured by the ability to provide a certain amount of current within 10 minutes before a "heat cut". This is the "duty cycle".

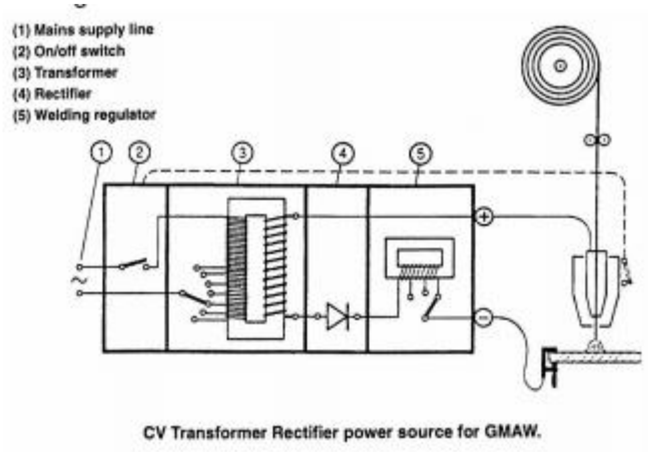

Fig. 1 CV Transformer rectifier power source for GMAW

2. Research methodology

The basic idea of statistical experimental design and the Department of Energy was born from the work of Sir Ronald Elmer Fisher in the 1920s. Fisher is the statistician who laid the foundation for modern statistical science. The second era of statistical experimental design began in 1951 with the work of Box and Wilson [6], applying this idea to industrial experiments and developing a surface response method (RSM), which was used to discover the relationship between different process parameters. Relationship. One or more responses. Although the work of Dr. Kenichi Taguchi in the 1980s caused much controversy (briefly described in Heading 2.4), it had a major impact on making statistical experiment design popular and emphasized its importance in improving quality.

2.1 Arc Flux Arc Welding (MCAW)

MCAW welding uses heat generated by the DC arc to melt the metal in the joint area, creating an effect between the continuous consumable filler wire and the workpiece, causing the filling wire and the work piece to melt nearby. The entire arc area is covered with a protective gas, which protects the molten welding pool from the air. Since MCAW is a variant of the MIG welding process, there are many common characteristics between the two processes, but there are also some basic differences. As with MIG, a DC power supply with a constant voltage output feature is used to provide welding current. For base metal wires, the terminals to which the filling wires are connected depend on the specific product used. (Some wires are designed to operate on the positive electrode, while others are designed to operate on the negative electrode, and some are operating in either direction.) Then connect the return wire to the other end. The electrode negative process usually provides better positioning weld properties. The power supply output characteristics may affect the welding quality of the product. The wire feeder takes the solder wire filled from a pulley or bulk bundle and feeds it into the arc through the welding gun at a predetermined speed and is precisely controlled. Generally, lathe feed rollers for base metal wire are used to help feeding and prevent crushing of weak parts.

Unlike MIG, which uses a consumable solid filler wire, the MCAW consumables are tubular structures, except for a small amount of non-metallic compounds, the entire metallic casing is completely filled with metallic powder. These are added to provide some arc stability and remove oxidation. MCAW consumers always require the same additional gas shield used by the solid MIG line. The welding wire is usually designed to work in an argon carbon dioxide mixture or argon carbon dioxide mixture. Argon-rich mixtures tend to produce smoke levels lower than CO2. Like MIG, the welding wire and the shielding gas are directed to the arc area by the welding gun. At the tip of the welding torch, the welding current travels to the welding wire via the copper alloy contacts, and the gas dispenser distributes the protective gas evenly around the shield, then the protective gas passes through the welding area. The position of the contact tip relative to the cap can be adjusted to reduce the minimum span of the electrode. MCAW Metal Transfer Mode is similar to MIG welding mode, and the process can be operated in “Immersion Transfer” and “Spray Transfer” modes. Basic metal wires can also be used in medium-low pulse transmission mode, but this is not widely used.

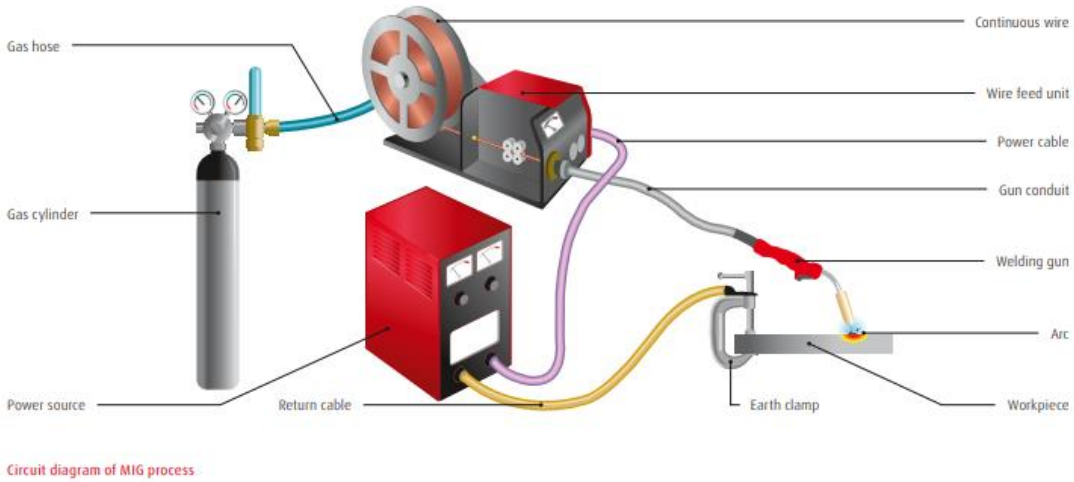

Fig. 2. Circuit Diagram of MIG Process

The method or type of metal transfer for MIG welding depends on the electric current, arc voltage, electrode diameter and the type of shielding gas used. Generally, there are four metal transfer patterns. The method of transferring metals using FCAW is similar to the one obtained in MIG welding, but the method of transportation here largely depends on the composition of the flow filling as well as the current and voltage.

3. Experimental design

In this research L27 array has been used as discussed in previous chapter. When the process variable designed by using Taguchi philosophy has been treated as input function for simulation model of MIG to generate the working hours for every machine per year, and also gives the throughput of system. According to objective of MIG throughput and system utilization are larger is better. So using larger is better in L27 array in Taguchi philosophy following plots and regression equations obtained.

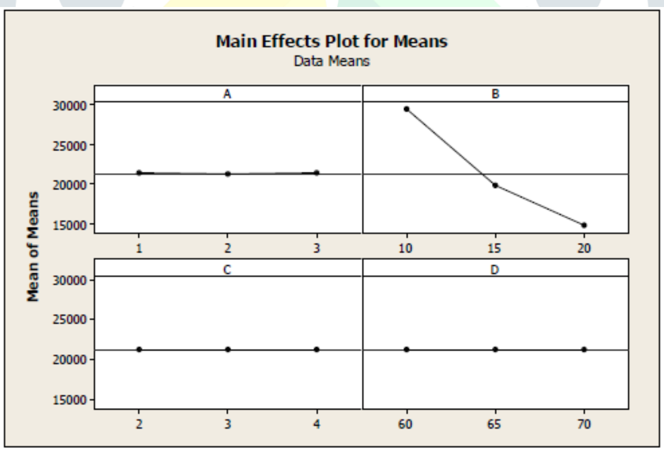

Fig. 3 : Main effect plot for means of throughput of system

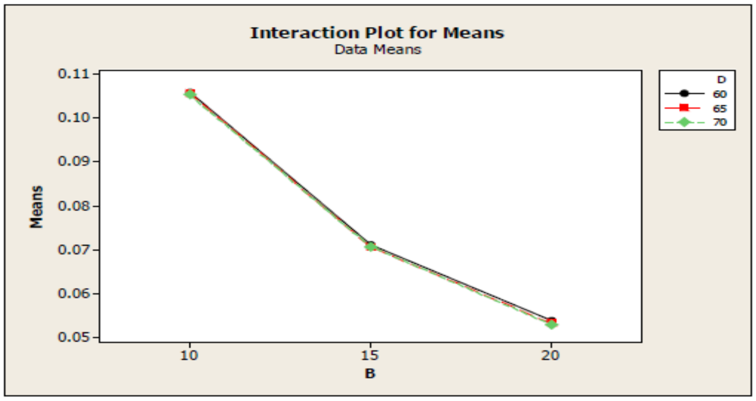

Fig. 4 Interaction plots for means between demand arrival time (B) and velocity of carts (D) for system utilization.
Interaction plots for means between demand arrival demand time (B) and velocity of carts (D) gives that as arrival demand time increases throughput of system decreases there is very less effect of velocity of carts on throughput according to this research in this problem.

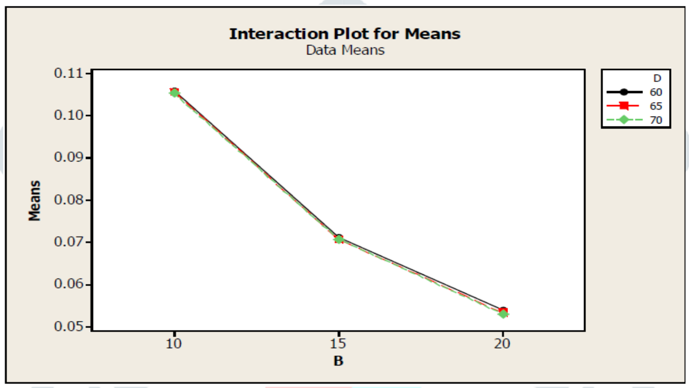

Fig. 5 Interaction plots for means between demand arrival time (B) and velocity of carts (D) for system utilization.
As shown in response table for means gives that demand time is more influencing factor than other factors. Than velocity of carts affects the system utilization and distance preference is very less influencing factor for throughput.

Table 1: Response table for means for throughput

Level	A	B	C	D
1	0.07681	0.10573	0.07675	0.07697
2	0.07628	0.07086	0.07659	0.07659
3	0.07684	0.05334	0.0766	0.07638
Delta	0.00056	0.05239	0.00016	0.0006
Rank	3	1	4	2

As shown in response table for means gives that demand time is more influencing factor than other factors. Than velocity of carts affects the system utilization and distance preference is very less influencing factor for system utilization

Table 2: Response table for system utilization

Level	A	B	C	D
1	21373	29453	21295	21315
2	21235	19732	21318	21317
3	21340	14763	21334	21316
Delta	138	14690	39	2
Rank	2	1	3	4

4.Optimization

In this research, system throughput of system and system utilization both are optimized by genetic algorithm, using genetic algorithm following results obtained as shown in table 6 and table 7 respectively for maximum throughput = 43321 -

17*distance preferences (X1) - 1469 *arrival demand + 19* no. of carts (X3) + 0.1 * velocity of carts (X4)

Table 3: factor and their level for maximizing throughput through genetic algorithm

Factors	Level	value
Distance Preference	Level1	Smallest distance
Demand Arrival time	Level1	10 minutes
No. of carts	Level3	4
Velocity of cart	-	62.501

Throughput obtained by value of above factor in simulation is 30013. System utilization = 0.159 + 0.00001 *distance preferences (X1) - 0.00524*arrival demand time (X2) - 0.00007 * no. of carts (X3) - 0.000060 * velocity of carts (X4)

Table 4: factor and their level for maximizing system utilization through genetic algorithm

Factors	Level	value
Distance Preference	Level1	Smallest distance
Demand Arrival time	Level1	10 minutes
No. of carts	Level3	4
Velocity of cart	-	69.941

System utilization obtained by value of above factor in simulation is 0.1071% Apart from the single objective functions considered for this problem, a combined function is also used to perform the multi-objective optimization for the MIG parameters. The function and the variable limits are given using following function. Equal weights are considered for all the responses in this multi-objective optimization problem. Hence W1 and W2 are equal to 0.5.

$$Z_{Multi} = w_1 * \frac{Z_{system\ utilization}}{system\ utilizationa_{max}} + w_2 * \frac{Z_{throughput}}{Throughput_{max}}$$

Using above function a following combined function obtained which is optimized by using genetic algorithm and gives results as shown in table 4.6 Z_{Multi} = 0.5 * (1.49155 - 0.0000938 * X(1) distance preferences - 0.049155 * X(2) arrival demand time + 0.0006566 * X(3) No. of carts + 0.0005628*X(4) Velocity of carts)-0.75*(1.4642 - 0.0005717 * X(1) distance preferences -0.49406 * X(2) arrival demand time +19 * X(3) No. of carts +0.0006390 * X(4) Velocity of carts).

Table 5: Factor and their level for maximizing throughput and system utilization through Genetic algorithm.

Factors	Level	value
Distance Preference	Level1	Smallest distance
Demand Arrival time	Level1	10 minutes
No. of carts	Level3	4
Velocity of cart	-	62.495
Throughput	-	30018
System utilization	-	0.1085%

5. Conclusion

In this research, we presented a simulation modeling and optimization of MIG welinding objectives for evaluating the effect of factors such as demand arrival time, no. of carts used in system, velocity of carts, and distance preference between two stations. System utilization and throughput both are affected by these factors. System utilization and throughput is more affected by demand arrival time comparatively other three factors. Distance preference also affects throughput and system utilization. For both system utilization and throughput distance preference should be smallest. And as the demand arrival time increases both system utilization and throughput of system decreases. No of carts and velocity of carts are less affected.

5.1 Future scope

The problems here solved are solved by following Genetic Algorithm. It is also observed that use of Genetic algorithm in integration with other meta heuristics like Tabu search, simulated annealing, neural networks to determine the optimized schedule in an MIG. It can also be solved by various other techniques such as particle Swarm Optimization and many others. Another approach can also be by following Adaptive Genetic Algorithm or by following higher Heuristic Approach. Generally, jobs are scheduled but simultaneous scheduling of jobs and machines remains the most interesting area to work on and this can do wonders to our industrial life. In this case, both, jobs and machines will work together and the make span time can be drastically reduced. It is also observed that use of Genetic algorithm in integration with other meta heuristics like Tabu search, simulated annealing, neural networks to determine the optimized schedule in an MIG.

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