OVAT Analysis for Improving Weld Quality in MIG Welding

Milind M. Ghogale
ME Scholar, Mechanical Engineering Department,
Government College of Engineering,
Aurangabad (MS)

Prof. S. A. Patil
Asst. Professor, Mechanical Engineering Department,
Government College of Engineering,
Aurangabad (MS)

Abstract:- **Quality of a weld is depends on welding input parameters. Weld penetration depth is one of the prime requirements of welded parts. The purpose of this research paper is focused on the analysis of MIG welding process parameters to get highest penetration in weld by regression analysis. This paper presents an OVAT (One Variable at a Time) analysis to investigate the effects of welding parameters like current, voltage, gas flow, Fixture Rotation speed and Wire feed rate on penetration on lever shaft.**
In any manufacturing industry, MIG welding is one of the most important and effectively used manufacturing method.. In today's manufacturing scenario, optimization of welding process is essential for a manufacturing unit to respond effectively to severe competitiveness and increasing demand of quality, which has to be achieved at minimal cost. In this investigation, an effective approach is based on OVAT .It has been developed to determine the optimum conditions to get highest penetration in welding. Experiments were conducted by varying current, voltage, gas flow, fixture rotation speed and wire feed rate on penetration using OVAT method. Experimental results from this are used for fixing the optimum parameters to get the high penetration. The relationship between process parameters and penetration depth. The experiment was conducted on "Lever Complete Gear Shaft Assembly" of Bajaj auto two wheeler . From the investigation it concludes that Current is most influencing parameter followed by Voltage and Gas flow on Penetration.

Keywords: MIG Welding; OVAT, Penetration depth.

1. INTRODUCTION

Metal Inert Gas welding is one of the most fundamental and most applied processes in a real manufacturing environment amongst the various manufacturing processes. Weld penetration has received important significance for many years. It has formulated an important design feature in many situations. Physical properties desired in any welded components are like tensile strength, Yield strength and, elongation. To achieve these physical properties, penetration is the key parameter to check. Weld penetration is the method of measuring the quality of a product and is an important parameter in welding process. It is one of the prime requirements of customers for welded parts [2].

1.1. MIG Welding Process :

A continuous consumable wire is fed through a suitable torch or gun which is used both as an electrode and filler, the gun or torch embodies a concentric gas nozzle which channels a protective gas which is usually fed from a separate cylinder out and around the newly formed weld preventing atmospheric contamination. The weld is formed due to the positive electrode (the continuous wire) coming into close contact with the negative electrode of the work piece allowing a large current to flow through the wire causing the tip to heat up beyond its melting point..
The type of gas or gas mixtures employed in welding varies with the metal being joined. To some extent the gas is chosen to reduce costs, the inert gases being very expensive, but more often the gas is chosen for its effect on the arc characteristics, e.g. burn off rate, type of metal transfer and penetration. These important parameters play a large part while selecting gas.

Gas mixture such as argon with carbon dioxide which combine the advantages of both gases. The main advantage of MIG welding process is high welding speed and greater deposition rates. In this process no slag is left behind, hence no need to clean the weld after finished welding operation; this saves lot of time of welder, enhancing the production rates. The important advantage is that low skill labour is required to operate the weld setup, provided all the welding process parameters are optimised. There is also one main advantage that, no stub end losses or wasted man hours for changing electrodes. A complete spool is employed as an electrode will last longer and is easily interchangeable.
MIG welding process can be easily automated with the help of welding fixtures and Robots.

MIG welding is the form of simple welding methods of metal welding as it does not require a high level of skill to achieve results. The process is semi-automatic because an electrode wire and gas are automatically fed through the gun at a user defined speed or pressure when the operator pulls down the trigger, the electronic arc can also be user defined and carried out automatically on operation. MIG is a quick and easy form of welding; it is used often by robotics in automated production lines.

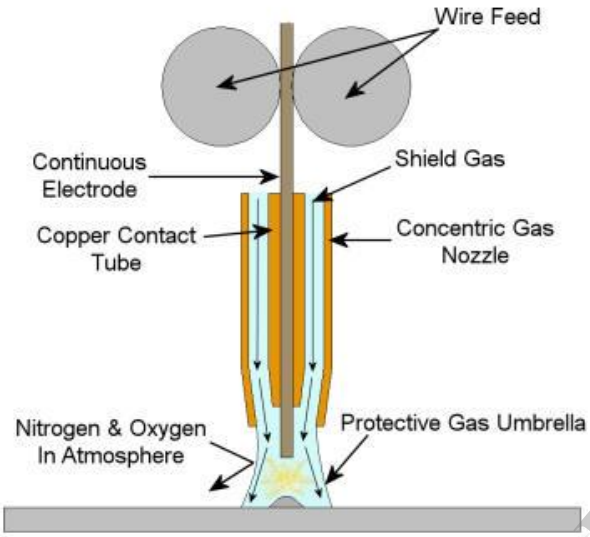


Figure 1 MIG Welding Process

The ability of a welding operation to produce a desired depth of penetration depends on various parameters. In welding process, the penetration depends on current, voltage, gas flow, welding speed, wire diameter. Even small changes in any of the mentioned factors may have a significant effect on depth of penetration. [4].

The aim of this study is to present and discuss the different optimization approaches and strategies in order to improve the depth of penetration based on the experimental research.

Before going to the main experimentation, some discussion with company peoples and with the help of research paper I have selected three input parameter like current, voltage and gas flow rate. By performing OVAT[3] (One Variable at a Time) analysis it is clear that current, voltage and gas flow rate, are influencing parameters on Penetration and selected three levels for each parameter according to results. According to OVAT analysis following input parameters namely current, voltage and gas flow rate, are selected by keeping other process parameters constant which are less influencing on Penetration.

2. EXPERIMENTAL DETAILS

2.1 OVAT experiments

A popular way to deal with the multi-variable nature of welding process optimization is the One Variable at a Time (OVAT) approach. Here, all experimental inputs, except one, are kept constant, e.g. current. An output, e.g. Penetration depth, is then recorded at multiple current values. In this way, the "optimal" current value is revealed. This current value is then kept constant and another variable is chosen, for example voltage. The process continues until all inputs have been probed and a set of optimal inputs have been determined. This helps in data analysis and estimation of optimum results. In this study we have consider 5 factors which affect majorly on quality characteristic such as Current, Voltage, Gas flow rate, Fixture rotation speed and wire feed rate. The design of experiment was carried out by OVAT. In this technique the main objective is to optimize the Penetration that is influenced by three input process selected for this investigation.

2.2 Selection of control factors

From the discussion with company peoples and with the help of research paper it strongly felt that the penetration is very important in lever complete gear shaft assembly as per customer requirement. So that Penetration in mm is selected as response parameter for experimentation.

2.3 Experimental set up

The essential equipments required for any MIG welding process, refer figure 2, are welding power source, Welding torch, Wire feed mechanism, shielding gas cylinder, Pressure Regulator, Flow meter, Gas preheater, Electrode wire, control panel, operator safety equipment and finally suitable welding fixture. A Series of experiment was conducted to evaluate the influence of MIG Welding process parameters on depth of penetration.

2.3.1 Power Source –

The test was carried out on JASIC MIG 350 SG Welding machine. The selection of welding machine is depends on material to be welded, overall dimensions, thickness of the material, It is thumb rule that minimum 25% of thickness should be the minimum penetration desired. It is obvious that larger is always better to achieve highest durability.

MIG welding is carried out on DC electrode (welding wire) positive polarity (DCEP). However DCEN is used (for higher burn off rate) with certain self shielding and gas shield cored wires.

DC output power sources are of a transformer-rectifier design, with a flat characteristic (constant voltage power source). The most common type of power source used for this process is the switched primary transformer rectifier with constant voltage characteristics from both 3-phase 415V and 1-phase 240V input supplies...

The overall components are considered and according to the minimum and maximum dimension of component, selection is carried out for a particular welding machine. Specification and description of machine is given in table 1 bellow.

Figure 2 MIG Welding setup

Table2.1 Specification and Description of machine

Specification	Description
Input supply voltage	415 V +/- 10%
Maximum input current	32 Amps R.M.S.
Recommended switch fuse	32 Amps
Rated power	23 KVA
Welding current	400 Amps D.C.
Open ckt. voltage	55 v DC max
Output welding current	50A-400A DC
Cooling	Air
Dimensions	600*500*280 mm
Weight	40 Kgs.

2.3.2 Wire feed mechanism-

The main function of wire feed mechanism is to deliver electrode to the torch at a constant speed or at different speed as per required by the component.

The wire spool is mounted near the feeding mechanism and through feeder the electrode is allow to pass through welding torch as specific speed.

The wire-feed unit, or sub-assembly where this is mounted in the power source cabinet (known as a composite MIG), provides the controlled supply of welding wire to the point to be welded. According to the welding wire size and

Arc voltage provided by the power source, a constant rate of wire speed is required, in MIG welding the power source provides Arc voltage control and the wire feed unit provides welding wire speed control, (in MIG this equates to welding current).d.

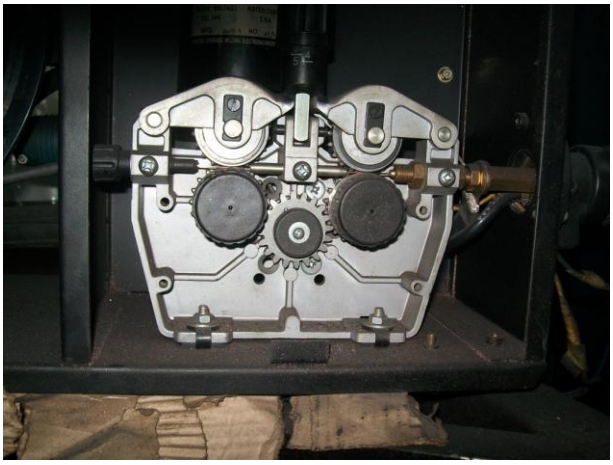


Figure 3 Wire Feed Mechanism

2.3.3 Gas preheater and Pressure Regulator-

The main objective is to regulate the pressure of the shielding gas and preheater is to maintain the temperature of gas optimum for the highest welding efficiency. The parameter setting is directly proportional to the consumption of the gas and hence has importance.

Figure 4 Gas Preheater and Pressure Regulator

2.4 Work material

A lever of Bajaj Discover-125 cc two wheeler selected for experimentation made of material cold rolled steel(Grade DD) and heat treated as carbonitriding and EN 9 Shaft. The penetration requirement is 0.75 mm minimum and 1.8 mm maximum in both shaft and lever . Our aim of this project is to achieve maximum penetration by optimising the process parameter without affecting cost.

Figure 5 Lever Complete Gearshift

3. EXPERIMENTAL CONDITIONS

A series of experiment was carried out on JASIC MIG 350 SG Welding Machine .From OVAT analysis five input controlling parameters selected . Details of parameters and their results used shown in the table and graphs.The experiment is done on lever complete gear assly.

All equipments are to be set with proper parameters like wire feed speed, Shielding gas cylinder pressure , Flow meter adjustment, Gas preheater temperature, Electrode wire spool positioning, , operator safety equipment setting and finally suitable welding fixture setting.

These are various initial setting for producing parts on MIG welding machines. Our project selected main contributing factors such as Current, Voltage, Gas flow, Fixture rotation speed and wire feed rate. Besides these parameters there are other process parameters like Air Pressure,

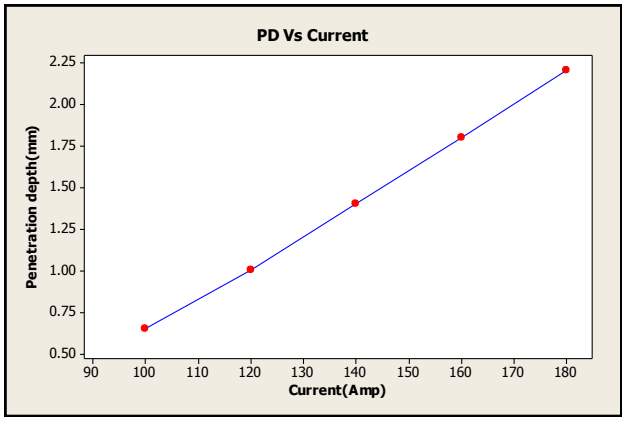
The above parameters are to be set for the optimum values so that the productivity, quality with the minimum cost is achieved. It is, hence, very essential to know the optimum process parameters.

3.1 Current

it is observed that with increase current by keeping other parameters like voltage, gas flow rate and wire feed are constant at mean level the penetration depth PD is continuously increasing.
Hence Current is influencing factor on PD. The levels of current are selected on the basis of penetration depth. Optimum penetration depth during welding process ranges from 0.75-1.80 mm. At 160 ampere a highest depth of penetration is 1.8 mm, so the optimum operating range selected for investigation is 120-160 ampere

Table 3.1 OVAT analysis of Current

Lever No.	Current (Amp)	Gas Flow (Lit/Min)	Ava. PD (mm)
1	100	20	0.65
2	120	20	1.0
3	140	20	1.4
4	160	20	1.8
5	180`	20	2.2



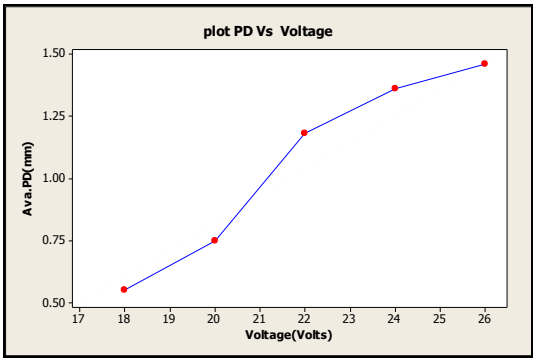
Graph 3.1 Scatter plot of PD Vs. Current

3.2 Voltage

From Table 3.2 it is clear that as the penetration depth is increasing from 0.55 mm to 1.46 mm by increasing the voltage, We have kept the current and gas flow rate constant, It shows that the effect of voltage is there in increasing the depth, but the first two values are out of acceptance limit, hence we have to choose the range of voltage on higher side .Hence we have chosen voltage range as 22-26 volts.

Table 3.2 OVAT analysis of Voltage

Lever No.	Current (Amp)	Voltage (Volt)	Gas Flow (Lit/Min)	Ava. PD (mm)
1	140	18	20	0.55
2	140	20	20	0.75
3	140	22	20	1.18
4	140	24	20	1.36
5	140	26`	20	1.46



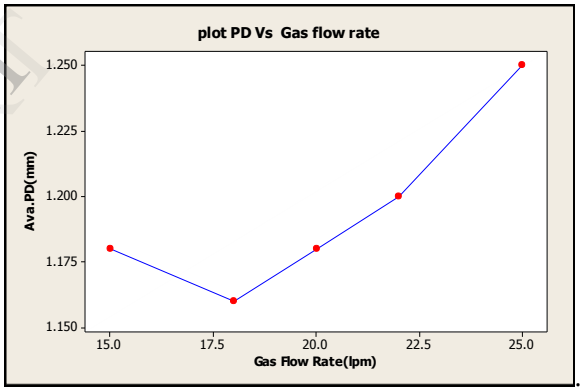
Graph 3.2 Scatter plot of PD vs. Voltage

3.3 Gas Flow Rate

From Table 3.3, it is clear that as the gas flow rate increase from 15 lpm to 25 lpm by keeping other parameters like Current, voltage constant, PD is not affecting much. As we can see the depth is varying from 1.16 mm to 1.25 mm, only. It is clearly indicates that the gas flow rate not having major influence on the depth of penetration.

Table 3.3 OVAT analysis of Gas Flow Rate

Lever No.	Current (Amp)	Voltage (Volt)	Gas Flow (Lit/Min)	Ava. PD (mm)
1	140	22	15	1.18
2	140	22	18	1.16
3	140	22	20	1.18
4	140	22	22	1.20
5	140	22`	25	1.25



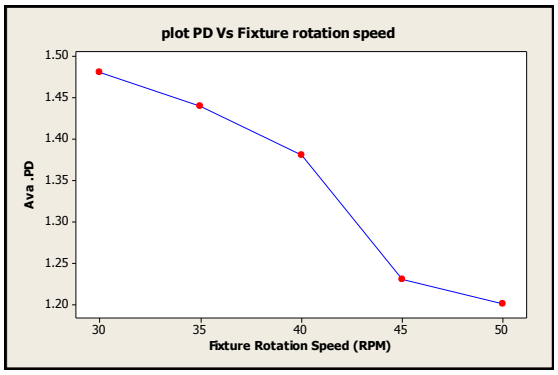
Graph 3.3 Scatter plot of PD vs. Gas Flow Rate

3.4 Fixture Rotation Speed

From Table 3.4, it is clear that as the fixture rotation speed increase from 30 rpm to 50 rpm by keeping other parameters like Current, voltage constant, PD is not affecting much. As we can see the depth is varying from 1.20 mm to 1.48 mm, only. It is clearly indicates that the fixture rotation speed is not having major influence on the depth of penetration. Hence we have chosen the practical values which are mainly to maintain the PD constant with minimum use of electrode wire

Table 3.4 OVAT analysis of Fixture Rotation speed

Lever No.	Current (Amp)	Voltage (Volt)	Fixture Rotation Speed (RPM)	Ava. PD (mm)
1	140	22	30	1.48
2	140	22	35	1.44
3	140	22	40	1.38
4	140	22	45	1.23
5	140	22`	50	1.20



Graph 3.4 Scatter plot of PD vs. Fixt.rotation Speed

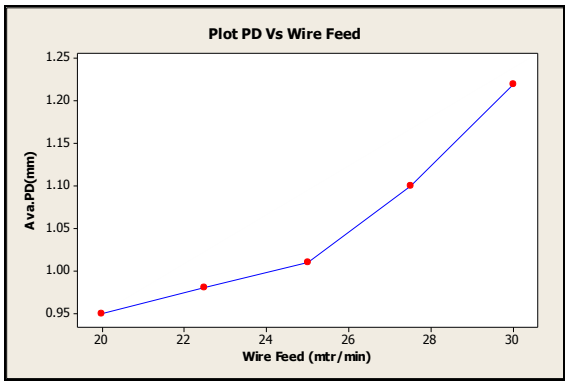
3.5 Wire Feed

From Table 3.11 it is clear that as the Wire Feed increase from 20 mtr/min to 30 mtr/min by keeping other parameters like Current, voltage constant, PD is not affecting much. As we can see the depth is varying from 0.95 mm to 1.22 mm.

It is clearly indicates that the Wire Feed is not having major influence on the depth of penetration. Hence we have chosen the practical values which are mainly to keep constant depth of penetration

Table 3.5 OVAT analysis of Wire Feed

Lever No.	Current (Amp)	Voltage (Volt)	Wire Feed (Mtr/Min)	Ava. PD (mm)
1	140	22	20.0	0.95
2	140	22	22.5	0.98
3	140	22	25.0	1.01
4	140	22	27.5	1.10
5	140	22`	30.0	1.22



Graph 3.5 Scatter plot of PD vs. Wire Feed

By performing OVAT analysis and from graph it is found that current, voltage, are influencing parameters and gas flow rate, fixture rotation speed and wire feed rate are less influencing parameter on PD. According to OVAT analysis following input parameters namely Current, voltage, gas flow rate are selected by keeping other process parameters constant.

Table 3.6 Process parameters and levels

PROCESS PARAMETER	LEVEL 1	LEVEL 2	LEVEL 3
Current (Amp)	120	140	160
Voltage (volts)	22	24	26
Gas flow rate (lpm)	15	20	25

4. CONCLUSIONS

OVAT analysis is very much important tool utilized widely in engineering analysis. This work is a part of ongoing research project and the preliminary results are presented in this article. Based on the results of the work, following conclusions could be made:

It is found that an increase of current generally improves penetration depth.

Experiments show that as voltage increases penetration depth also increases..

Increasing the gas flow rate slightly increase the depth of penetration. As a result, Fixture rotational speed decrease the depth of penetration and As wire feed increase there is slight variation in the depth of penetration

REFERENCES

[1] K.Y. Benyounis, A.G. Olabi; "Optimization of different welding processes using statistical and numerical approaches – A reference guide." Advances in Engineering Software 39 (2008) 483–496

[2] Friedman, M., and Savage, L. J. (1947), "Planning Experiments Seeking Maxima," in Techniques of Statistical Analysis, eds. C. Eisenhart, M. W. Hastay, and W. A. Wallis, New York: McGraw-Hill, pp. 365-372.

[3] Daniel , C.,"One-at-a-Time Plans," Journal of the American Statistical Association 68, 353-360

[4] H.J. Park, D.C. Kim, M.J. Kang, S. Rhee; "Optimisation of the wire feed rate during pulse MIG welding of Al sheets." Journal of Achievements in Materials and Manufacturing Engineering Volume 27, by International OCSCO world

[5] Taguchi G, Konishi S. Taguchi methods, orthogonal arrays and linear graphs, tools for quality American supplier institute. American Supplier Institute; 1987 [p. 8–35]

[6] Taguchi G, Konishi S. Taguchi methods, orthogonal arrays and linear graphs, tools for quality American supplier institute. American Supplier Institute; 1987 [p. 8–35].

[7] Dinesh Mohan Arya,Vedansh chaturvedi,Jyoti vimal, 'Application of Signal to Noise Ratio Methodology for Optimisation of MIG process parameters" IJERA,Vol 3,No-4.