IMPACT OF TIG WELDING PARAMETERS ON WELD BEAD GEOMETRY

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Abstract: Everywhere in the world researchers are trying to optimize process parameters so that the next time same process parameters are implemented, parameters that are already optimized should be taken into consideration on the first priority level so that the results hence obtained are authentic to an excruciating degree, and a good quality and productivity may be achieved by that particular process.

On the contrary what is quite apparent on the ground level is that the stipulated and optimized researched parameters are used in the industry but because of some human errors, environmental conditions, and calibration ambiguity that creep in during the process, the goal of cent percent quality and productivity is not fulfilled.

In this study an attempt is made to bridge the gap between the vision of the researchers and the reality on the ground level, and for doing this we need something or someone who keeps a track record of all the included process variables in real time, pre-operation, during the operation, and post operation. The first thing that can be thought of for accomplishing this task is automation, now automation consist of two major parts hardware and software, hardware is something that is used to accomplish a task but the thing that controls the process variables in real time is the software. So software needs to be trained to keep a constant check on the process variables.

To train sophisticated software the optimized process variables is a pre requirement. The optimized process parameters can be taken from two sources first is the research studies that have been carried out in past and second is that we can test the process with the required process input variables an then get the optimized values on the first hand, which are hundred percent reliable. In this study tungsten inert gas welding or more popularly known as gas tungsten arc welding is taken in to account and the most effective parameters will be assessed according to the design of experiment provided by the design expert 9 software and experiments will be conducted accordingly, and at the last the optimum values will be noted.

1. Introduction

Undoubtedly welding is the most economic, most versatile and the most efficient joining process that is prevalent in the industry. Welding is the most widely used joining process in the manufacturing industry as well as intra-industry as this process combines the advantages of feasibility, reliability, and ease of use [14]. In the welding process scenario two parts or more than two parts of same material or may be different material are coalesced at their assembly or contacting surfaces by a suitable selection and input of heat and/or application of pressure. Largely welding applications are carried on by heat alone, with no pressure application; other by a mutual combination of pressure and heat; and still others by without any external heat supply but by pressure alone. A specific filler wire may or may not be added to the weld pool to enhance the permanent joint. The joint hence formed by the above welding process is known as a weldment. The word joining is broadly used for soldering, brazing, welding, and adhesive bonding, which turns out to be a strictly permanent joint between the parts and the present joint that is formed cannot easily be separated, on the other hand mechanical methods of combining different constituent parts together is usually referred as assembly. The applications are unrestricted to manufacturing and service industry, but have crossed leaps and bounds to maintenance and repair industry. The scope of the above process has unleashed its potential from the feasibility of a metal bed to the most highly engineered and sophisticated aircrafts and spacecrafts. Welding has a significant role in the ship building industry (anchors, submarines, ships, etc.), mechanical industry (tools, machines, supporting equipment's), aerospace (spacecrafts, spacesuits, shuttle), automotive industry (LMVs, trucks, tractors, buses), construction (skyscrapers, bridges, mixers), etc [14].

2. Literature Survey

R. P. Singh, et al. (2013) this study targets the probe of production of a simple and precise model for determination of the weld bead width of butt joint of submerged metal arc welding procedure [11]. **K. Ashok Kumar, et al. (2013)** the aim of this research work was to evaluate the relation between the weld quality and the gas tungsten arc welding process parameters [20].

Xueping, et al. (2013) in the present research work an experimental approach is used to develop a two-dimensional numerical model that will give an information about the arc characteristics of the gas tungsten arc welding with a two-electrode configuration [24]. **R. Sathish, et al. (2012)** A large application of gas tungsten arc welding is in the fields where a joint between two dissimilar metals is required [23]. **Indira Rani, et al. (2012)** this paper is based on the fact that automation is creeping into welding industry at very high pace and that scenario is not far away when more machines will be quite apparent in the industry than the men [22]. **D. Katherasan, et al. (2012)** this paper studies the weld geometry such as weld reinforcement, bead width, and depth of penetration of AISI 316L. Bead-on-plate welding technology was used to make welds on AISI 316L (N) austenitic stainless-steel using flux cored arc welding process [7]. **K. Abbasi, et al. (2012)** assessed the effect of metal inert gas input parameters on the bead geometry and shape factor of bright drawn mild steel specimen the arc voltage, welding speed, heat input rate, welding current are taken as welding input parameters [1]. **T. W. Eagar (2011)** during the past decades the automated welding has grown many folds. In United States only, the sale of electrodes for semi-automatic and automatic welding has grown about 6 times [21].

M. Aghakhani, et al. (2011) in the present paper gas tungsten arc welding is assessed. Taking previous literatures in to consideration it is noted that optimum selection of welding input parameters is a necessary step to obtain a good quality weld [19]. **Ghosh, et al. (2011)** in this paper submerged arc welding process is taken into consideration, to predict the heat-affected zone the concept of temperature bifurcation is important to attain the desired bead geometry [5]. **R. Sudhakaran, et al. (2011)** it is a fact that weld quality is a direct function of depth of penetration and shallow depth of penetration may be one of the potential reasons for a failure of a weld joint as penetration defines the stress carrying capacity of a weld joint. In this particular study a relationship has been established for a 202 grade stainless steel plates between the input process variables and the depth of penetration for GTAW. Four factors at five levels each have been investigated with central composite rotatable design and thirty-one experimental runs were conducted [16].

3. Scope and objectives

An extensive investigation has been carried out in the present study on the most influential parameters that generally are responsible for shaping the bead geometry of the welded joint, but then also there are some site specific or we can say application specific parameters such as welding gun angle, filler addition angle etc. that also can be incorporated in the further study and then a whole set of optimized parameters will be available as a handful information that is a prerequisite for a perfect welded joint.

In this study IS 2062 E250 Mild steel has been taken into consideration, taking into account its versatile application and weld ability, furthermore all other metals that find application in the industry and even the joining of dissimilar metals can be included in the study to enhance the sophistication of the research.

4. Methodology

Step:1 Selection the base and filler material: Base material selected for the study is IS 2062 E250 Mild steel the chemical composition is as follows.

Table 4.1 Base material chemical composition

Base Material	C%	Mn%	S%	P%	Si%	Fe%
IS 2062 E250	0.20	1.50	0.04	0.40	0.40	97.61

Table 4.2 Filler material chemical composition

Filler	C%	Mn%	Si%	Cr %	Mo%	P%	S%	Cu%
ER 80S-B2	0.09	0.55	0.48	1.35	0.55	0.012	0.006	0.15

Step:2 Selection of Parameters: The most influential parameters that were selected are: Welding current (I), Welding speed (s) and Gas flow rate. The working range for each process parameter was calculated by inspecting the weld bead geometry for a smooth appearance and ensuring that no visible defects are apparent like undercuts and surface porosity. The minimum values were designated by a (-) negative sign while the minimum was assigned a (+) sign.

Table 4.3 Levels of the effect parameters

Factors	Units	Notations	Level (-)	Level (+)
Welding current	Amperes	A	150	160
Welding speed	mm/sec	V	180	200
Gas flow rate	L/min	Q	10	15

Step:3 Design of experiment by Design Expert 9.0.2

Table 4.4 Design matrix

Run	Current (Level)	Speed (Level)	Gas flow (Level)
1	(-)	(-)	(-)
2	(-)	(-)	(+)
3	(-)	(+)	(-)
4	(-)	(+)	(+)
5	(+)	(-)	(-)
6	(+)	(-)	(+)
7	(+)	(+)	(-)
8	(+)	(+)	(+)

For a two-level full factorial experiment, the number of runs is calculated by the formula 2^K where K is the number of factors taken in consideration, so for the present study we have three factors so the design matrix has eight runs.

Step:4 Experiments execution in strict accordance with the design sheet: Bead on plate welding was performed on the test plates according to the design of experiment which was three factors at two levels design. For avoiding any human and environmental errors that may have crept in three replications of each set of experiment was done. A welding helmet was used as a protective gear for the eyes, the gas flow was regulated manually and flow rate was checked with the flow meter.

5. Result and discussion:

Table 5.1 Response data.

Run/ Trail	A: Current (Ampere)	B: Speed (mm/min)	C: Gas Flow rate (litres/min)	Response1 Penetration (mm)	Response 2 Bead width (mm)	Response3 Reinforcement (mm)
1	150	200	15	0.72	4.94	0.91
2	160	200	15	0.81	4.33	1.60
3	150	180	10	1.28	4.96	0.91
4	160	200	10	0.87	3.05	0.60
5	160	200	15	0.82	3.80	1.63
6	150	180	10	1.29	4.97	0.88
7	160	200	10	0.86	3.15	0.62
8	150	180	15	0.92	4.56	0.55
9	150	200	10	0.88	4.40	0.50
10	150	200	15	0.74	4.92	0.88
11	150	180	15	0.89	4.68	0.58
12	160	180	10	1.33	5.01	0.72
13	150	200	10	0.86	4.31	0.79
14	160	180	15	1.12	4.95	0.73
15	160	180	10	1.32	5.02	0.60
16	160	180	15	1.14	4.35	1.01

5.0 Response interpretation: - Maximum and minimum values for the penetration are 1.33mm and 0.72mm respectively. When bead width is assessed maximum and minimum values are 5.02mm and 3.15mm respectively, and in the case of reinforcement maximum and minimum values are 1.63mm and 0.55mm respectively.

5.1 Impact of current on penetration: In this graph (Fig. 5.1) effect of single factor is shown on the penetration. Here we see that the penetration decreases with the decrease in current and vice versa.

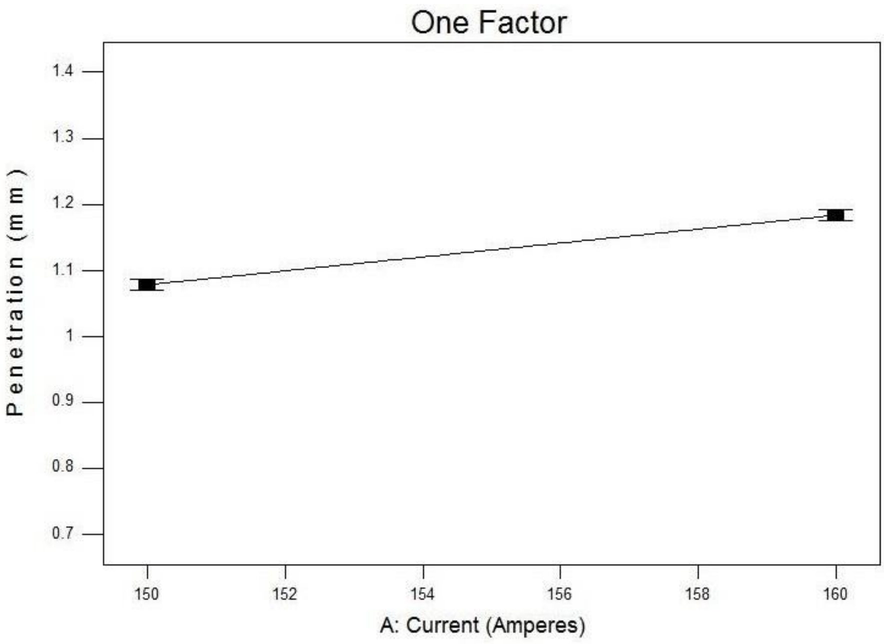

Fig 5.1 Penetration Vs Current

5.2 Effect of speed on penetration

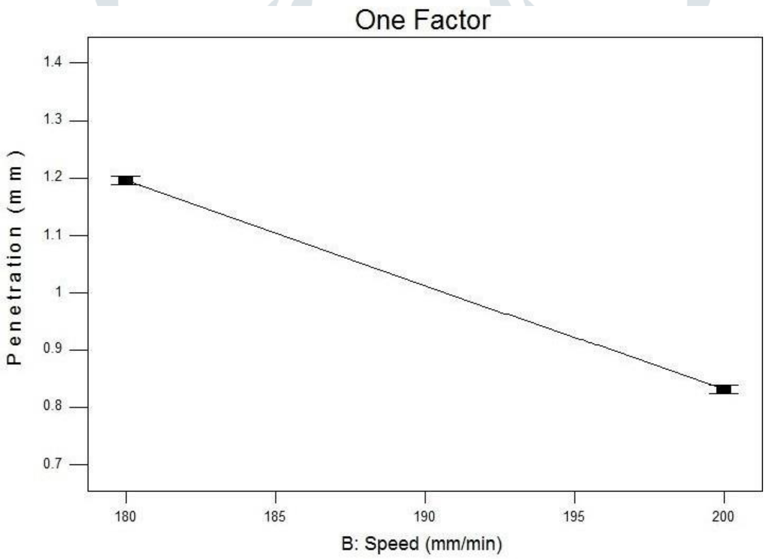

Fig 5.2 Penetration Vs speed [28]

In this graph (Fig 5.2) effect of single factor is shown on the penetration. Here we see that the penetration is increasing with the decrease in speed and is decreasing with the increase in speed.

5.3 Effect of gas flow on penetration: In this graph (Fig 5.3) effect of single factor is shown on the penetration. Here we see that the penetration is increasing with the decrease in gas flow rate and is decreasing with the increase in gas flow rate.

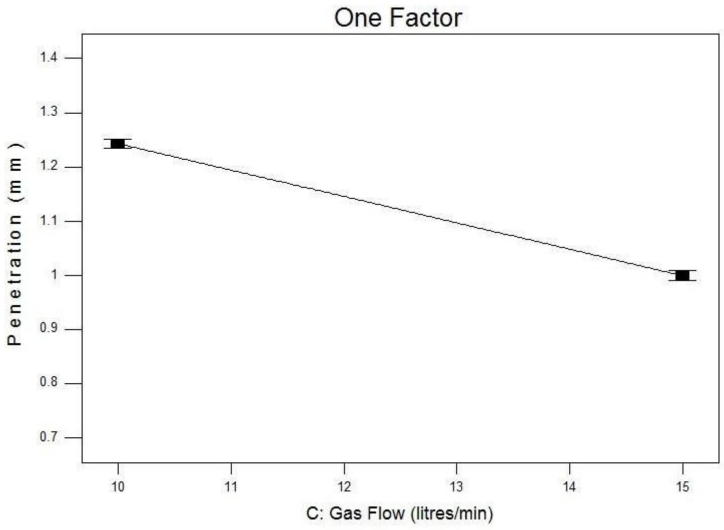

Fig 5.3 Penetration Vs Gas flow [28]

5.4 Interactive effect of speed and current on penetration.

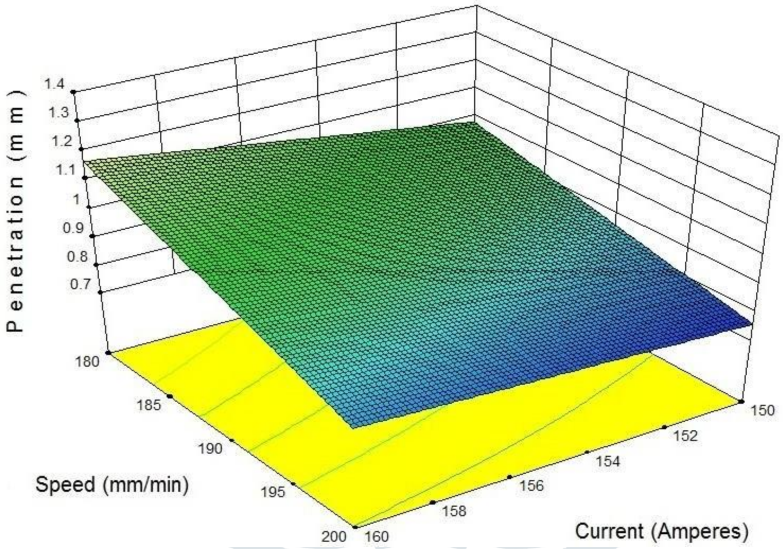

Fig 5.4 Interactive effect of speed and current on penetration. [28]

In this three-dimensional graph (Fig 5.4) combined effect of S and I is shown on the penetration of the welded joint. From this graph it is observed that when the speed is decreased and current is increased, the penetration is maximum and, in the case when speed is increased and current is decreased, the penetration in minimum.

5.5 Impact of gas flow rate and speed on penetration.

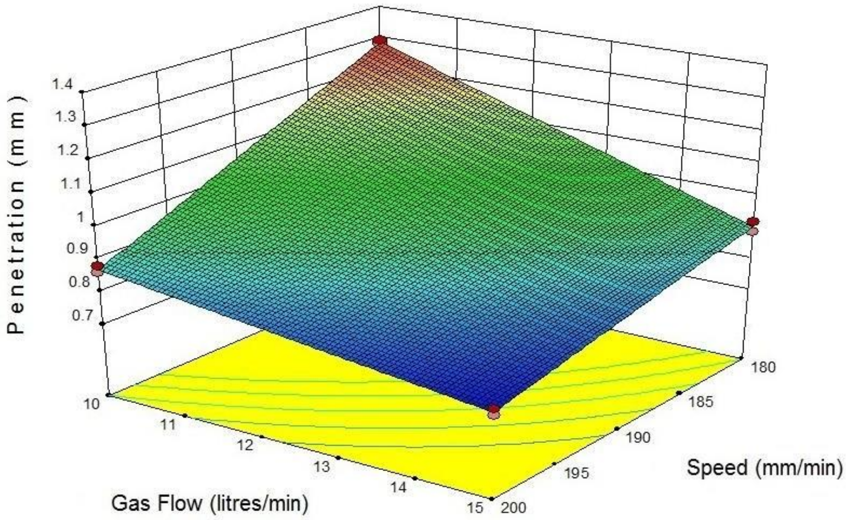

Fig. 5.5 Impact of gas flow rate and speed on penetration.

In this three-dimensional graph (Fig 5.5) combined effect of gas flow and speed is shown on the penetration of the welded joint. From this graph it is observed that when the gas flow is decreased and speed is also decreased, the penetration is maximum and, in the case when gas flow is increased and speed is also increased, the penetration in minimum.

5.6 Impact of current on bead width.

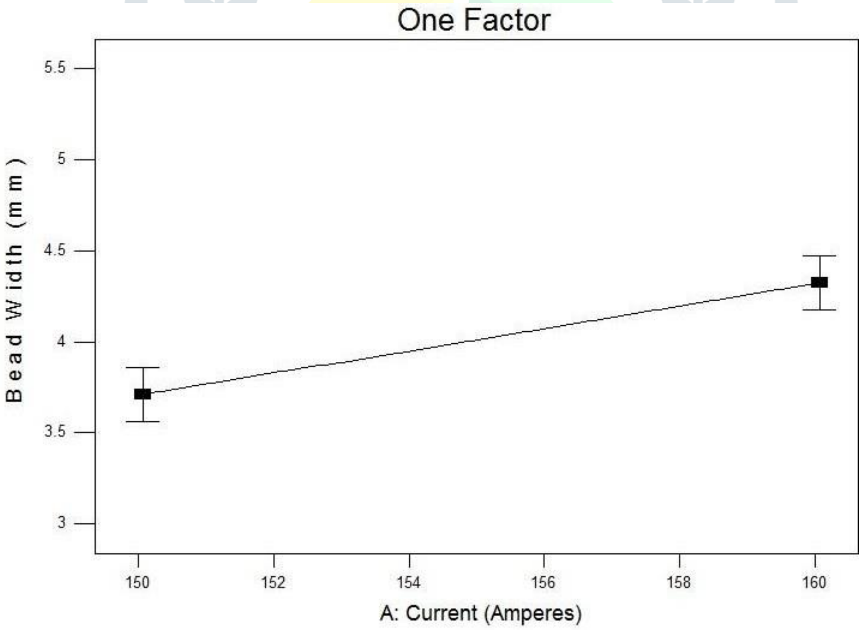

Fig. 5.6 Bead width Vs Current [28]

In this graph (Fig 5.6) effect of single factor is shown on the bead width. Here we see that the width of bead increases with the increase in current and is decreasing with decrease in current.

5.7 Effect of speed on width.

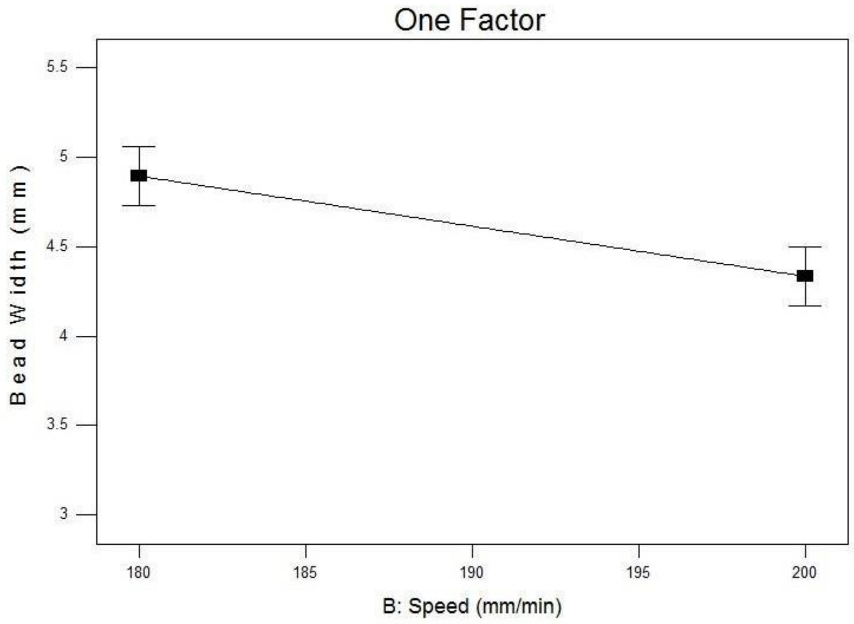

Fig. 5.7 Bead width Vs Speed [28]

In this graph (Fig. 5.7) effect of single factor is shown on the bead width. Here we see that the width of bead is increasing with decrease in speed and is decreases with the increase in speed.

5.8 Impact of gas flow on width of bead

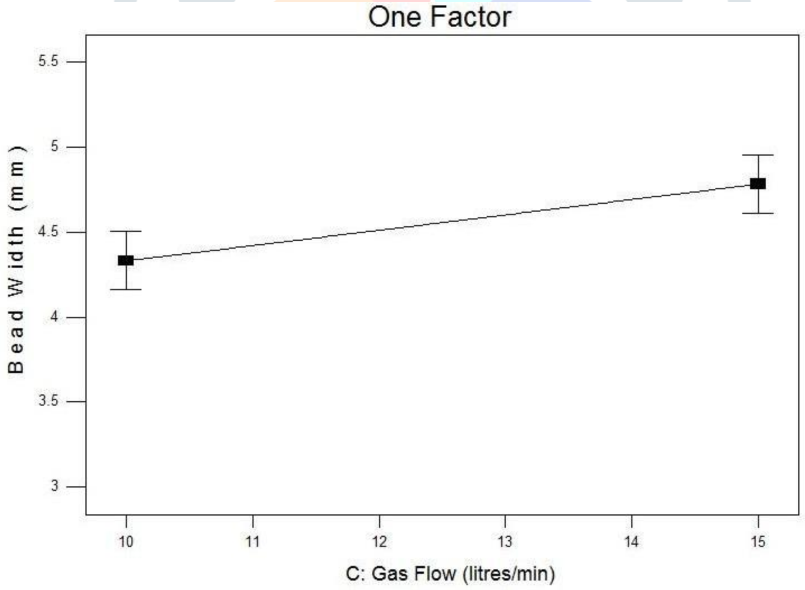

Fig. 5.8 Bead width Vs Gas flow

In this graph (Fig 5.8) effect of single factor is shown on the bead width. Here we see that the bead width is increasing with the increase in gas flow and is decreasing with the decrease in gas flow.

5.8 Impact of current(I) and speed(s) on bead width.

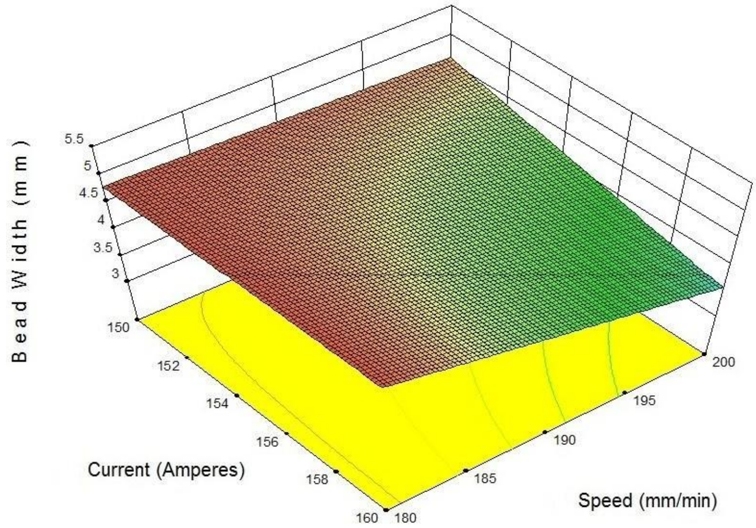

Fig. 5.9 Interactive effect of current and speed on bead width. [28]

In this three-dimensional graph (Fig 5.9) interactive effect of current and speed is shown on the bead width of the welded joint. From this graph it is observed that when the current is decreased and speed is also decreased, the bead width is maximum and, in the case when current is increased and speed is also increased.

5.9 Impact of current(I) and gas flow on bead width.

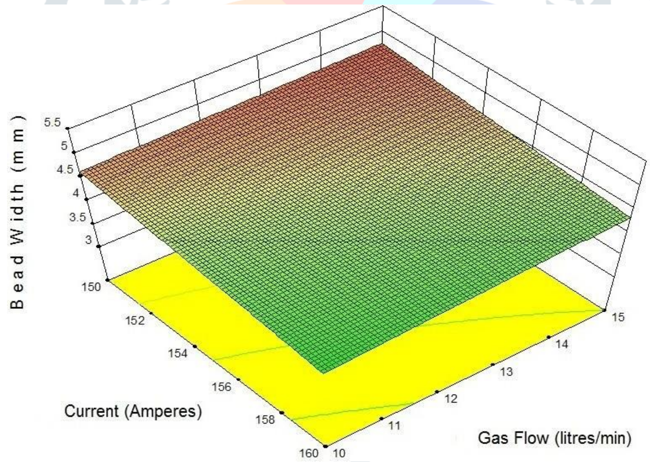

Fig. 5.10 Combined effect of current and gas flow on bead width.

In this three-dimensional graph (Fig 5.10) combined effect of current(I) and gas flow rate is shown on the bead width of the welded joint. From this graph it is observed that when the current is decreased and gas flow is increased, the bead width is maximum and, in the case when current is increased and gas flow is decreased, the bead width in minimum.

5.10 Impact of speed and gas flow on bead width.

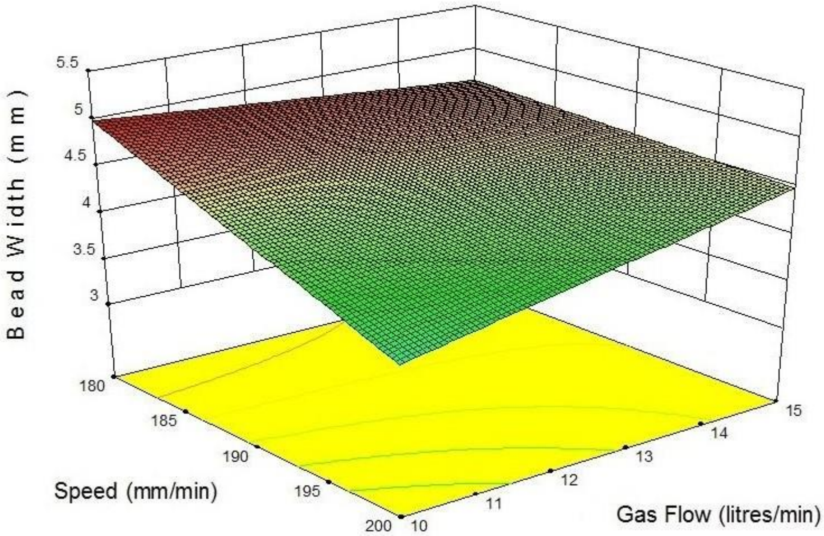

Fig. 5.11 Effect of speed and gas flow on bead width

In this three-dimensional graph (Fig. 5.11) combined effect of speed and gas flow is shown on the bead width of the welded joint. From this graph it is observed that when the speed is increased and gas flow is decreased, the bead width is minimum and, in the case when speed is decreased and gas flow is increased, the bead width in maximum.

5.11 Impact of current on reinforcement: In this graph (Fig. 5.12) effect of single factor is shown on the reinforcement. Here we see that the reinforcement is increasing with the decrease in current and is decreasing with the increasing current.

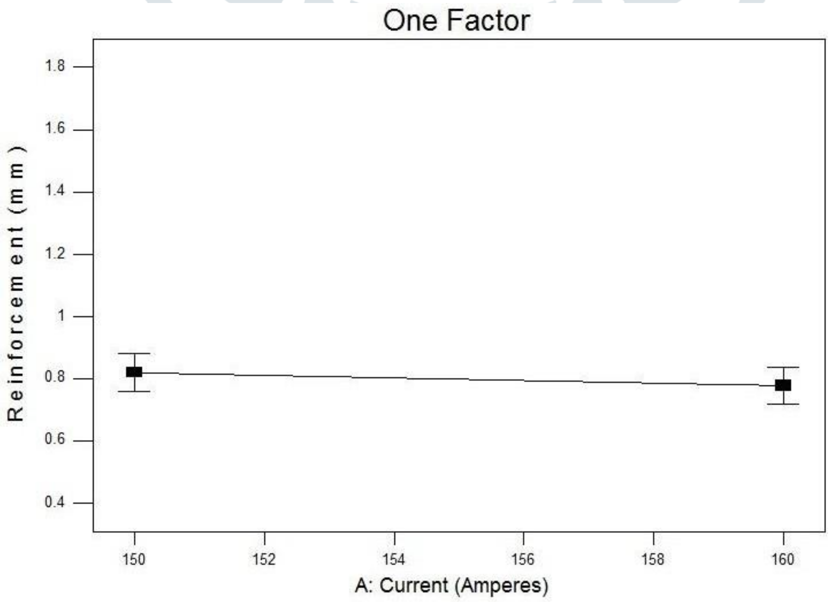

Fig. 5.12 Reinforcement Vs Current

5.12 Impact of speed on reinforcement:

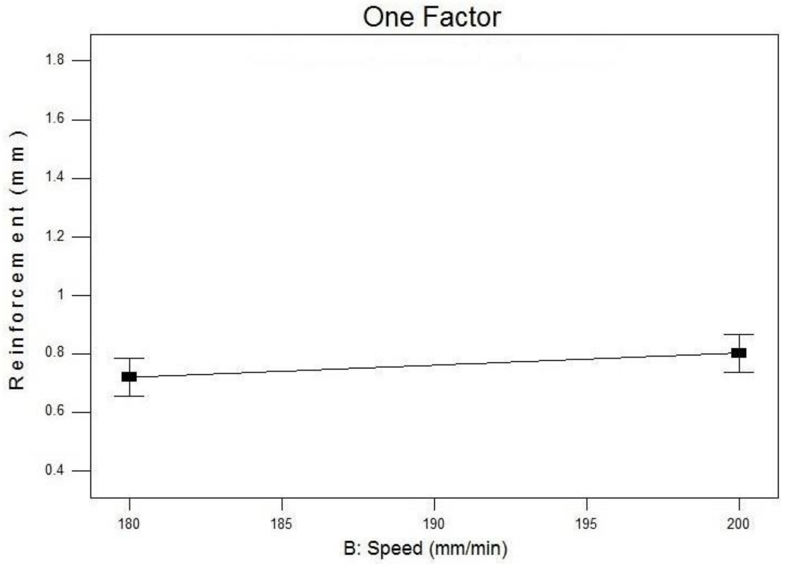

Fig. 5.13 Reinforcement Vs speed

In this graph (Fig. 5.13) effect of single factor is shown on the reinforcement. Here we see that the reinforcement is increasing with the increase in speed and is decreasing with the decrease in speed.

5.13 Effect of gas flow on reinforcement.

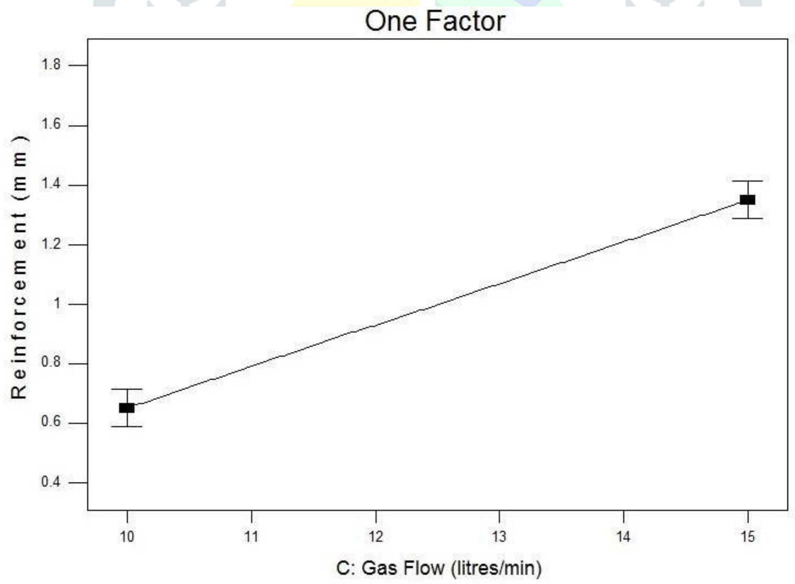

Fig. 5.14 Reinforcement Vs Gas flow

In this graph (Fig. 5.14) effect of single factor is shown on the reinforcement. Here we see that the reinforcement is increasing with the increase in gas flow and is decreasing with the decrease in gas flow.

5.14 Impact of current(I) and speed(s) on reinforcement.

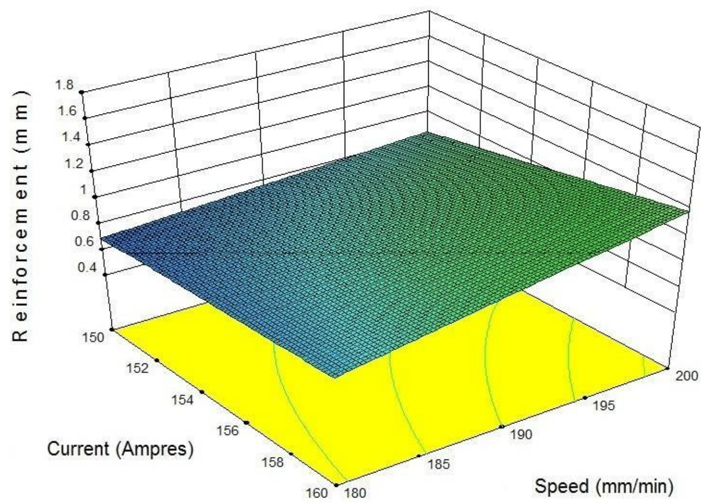

Fig. 5.15 Interactive effect of current and speed on reinforcement. [28]

In this three-dimensional graph (Fig. 5.15) combined effect of speed(s) and current(I) is shown on the reinforcement of the welded joint. From this graph observed that when the speed is increased and current is also increased, the reinforcement is maximum and, in the case when speed is decreased and current is also decreased, the bead width in minimum.

5.15 Impact of current(I) and gas flow on reinforcement.

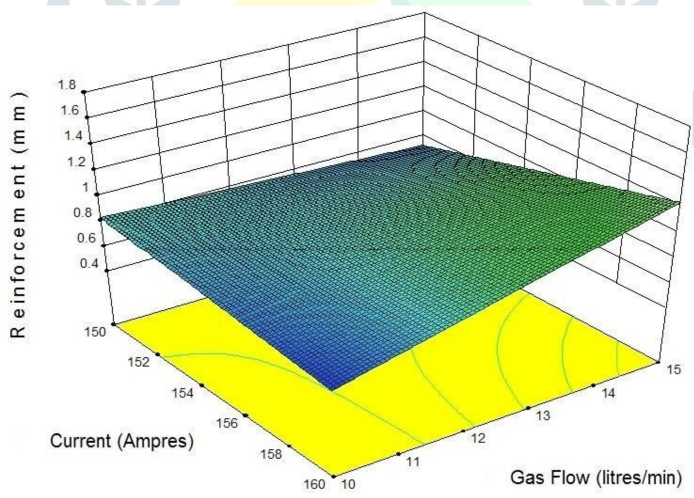

Fig. 5.16 Interactive effect of current and gas flow on reinforcement [28]

In this three-dimensional graph (Fig. 5.16) combined impact of current(I) and gas flow is shown on the reinforcement of the welded joint. From this graph it is observed that when the gas flow is increased and current is also increased, the reinforcement is maximum and, in the case when gas flow is decreased and current is also decreased, the bead width in minimum.

5.16 Effect of speed(s) and gas flow on reinforcement.

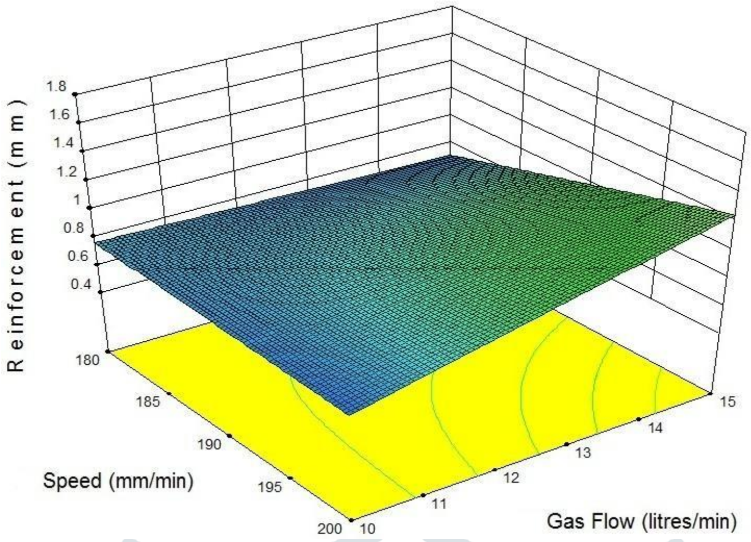

Fig. 5.17 Combined effect of speed and gas flow on reinforcement

In this three-dimensional graph (Fig 5.17) effect of speed and gas flow is shown on the reinforcement of the welded joint. From this graph it is observed that when the gas flow is increased and speed is also increased, the reinforcement is maximum and, in the case when gas flow is decreased and speed is also decreased, the bead width in minimum.

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