A Review on Parameters Controlling Gas Metal Arc Welding (GMAW) Process

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***Abstract*-- The gas metal arc welding process is increasingly employed for fabrication in many industries. The process is versatile, since it can be applied for all welding positions. Weld bead size, shape and penetration depend on number of parameters. Lot of research work has been done regarding the effect of variables on the process. Based on study of various works, the present paper provides a review of four parameters on the welding process namely welding current, welding speed, arc voltage and shielding gas. The effect of all the four parameters on various samples has been individually explained.**

***Index Terms*-- Gas Metal Arc Welding (GMAW), Welding current, arc voltage, welding speed, shielding gas**

I. Introduction

Gas metal arc welding (GMAW) process is an important component in many industrial operations. The GMA welding parameters like welding current, welding speed, arc voltage are the most important factors affecting the quality, productivity and cost of welding joint. Weld bead geometry directly affects the cost of welding. Hence these parameters are necessary to be controlled after careful study. Shielding gas used in the process not only protects the molten metal pool and keeps arc stable, but also affects the properties of weld and determines the shape and penetration patterns. Changing the weld parameters (weld speed, welding current, arc voltage) and changing the composition of shielding gas, creates changes in penetration. Lot of research work has been done in this area. The present paper provides a review on effect of these parameters after study of various research works done in the field. Effect of change in welding speed, welding current and arc voltage are presented on basis of test results on Erdemir 6842 steel and effect of composition of shielding gas is presented on basis of test results on ST-37-2 steel. Composition of the test materials are as follows:

TABLE I
Composition of Test Materials [1,2]

Material	C	Mn	Si	S	P
Erdemir-6842	0.16	0.72	0.07	0.004	0.013
ST-37-2	0.113	0.417	0.024	0.01	0.007

Test results for the first sample include three different current values (95A, 105 A and 115 A), three different voltage values (22V, 24 V & 26 V) and three different welding speeds (40cm/min, 60cm/min and 80cm/min). Three different variables were combined in 27 patterns. Test results for the second sample include four different combinations of shielding gas. (97.5% Ar+2.5%CO_2, 90% Ar+10%CO_2, 82% Ar+18%CO_2, 75% Ar+25%CO_2)

II. Effect of Welding Current

The effect of changing the welding current keeping the other parameters constant can be explained on basis of following graphs:

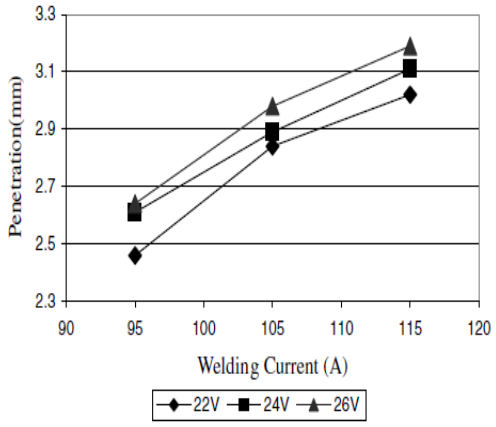


Fig. 1: Penetration vs Welding current for 40cm/min [1]

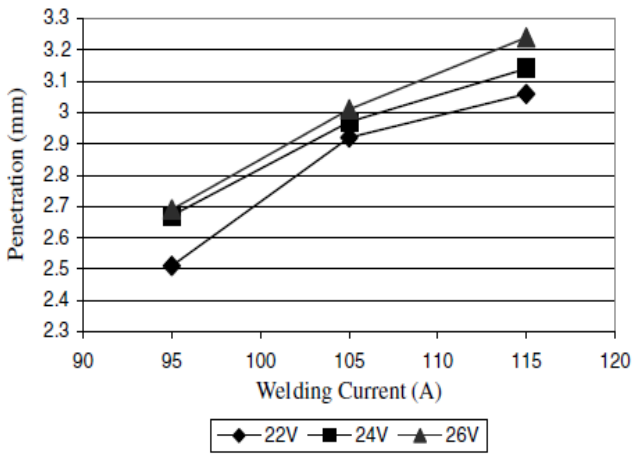


Fig. 2: Penetration vs welding current for 60cm/min [1]

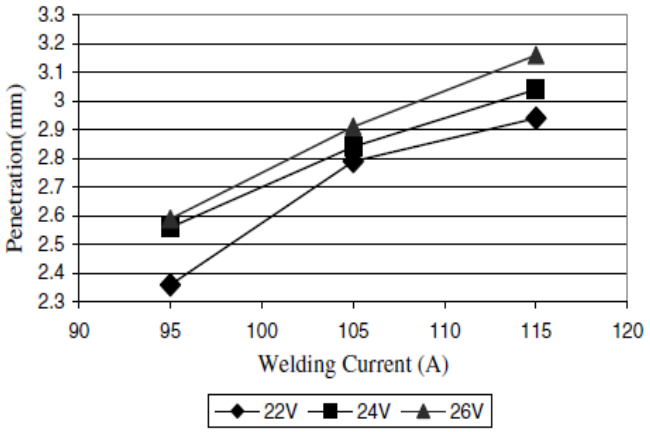


Fig. 3: Penetration vs welding current for 80cm/min [1]

The above graphs reveal that for speed of 40cm/min, the increase in penetration for 22V is 0.56mm, for 24V it is 0.5mm and for 26V, the increase is 0.55mm when the current value increases from 95A to 115A (increase of 20A).
Similar effect is observed for the speed of 60cm/min and 80cm/min. Hence, depth of penetration increases almost linearly with increase in welding current. Also the higher increase is observed when current is increased from 95A to 105 A than increase from 105A to 115A.

III. EFFECT OF ARC VOLTAGE ON PENETRATION:

The effect of change in arc voltage can be observed from following graphs.

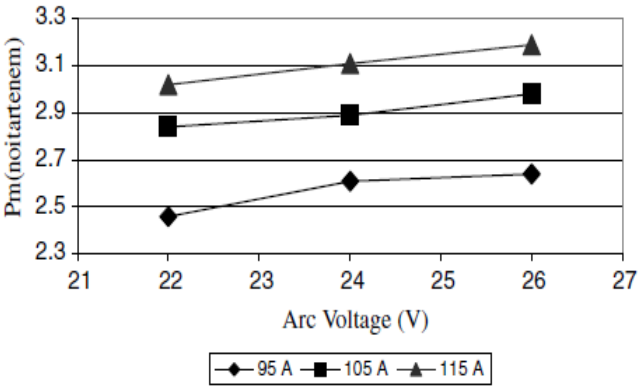


Fig. 4: Penetration vs arc voltage graph for 40cm/min welding speed [1]

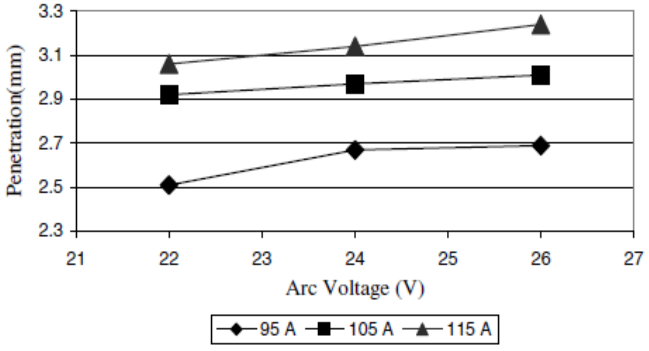


Fig. 5: Penetration vs arc voltage graph for 60cm/min welding speed [1]

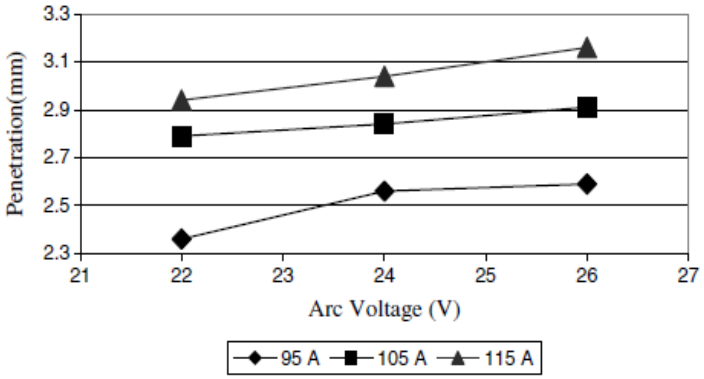


Fig. 6: Penetration vs arc voltage graph for 80cm/min welding speed [1]

The above graphs show that for speed of 40cm/min, the increase in depth of penetration for 95A, 105A and 115A is 0.18, 0.14 and 0.17 mm respectively for increase of 4V. When the speed was increased to 60cm/min, the observed increase in penetration is 0.18mm, 0.09mm and 0.18mm for current values of 95A, 105A and 115A respectively. The study of graphs reveal that as arc voltage increases the depth of penetration also increases. However compared increase in current, the effect is less.

IV. EFFECT OF WELDING SPEED ON PENETRATION:

To understand the effect of welding speed on penetration, the following graphs are provided

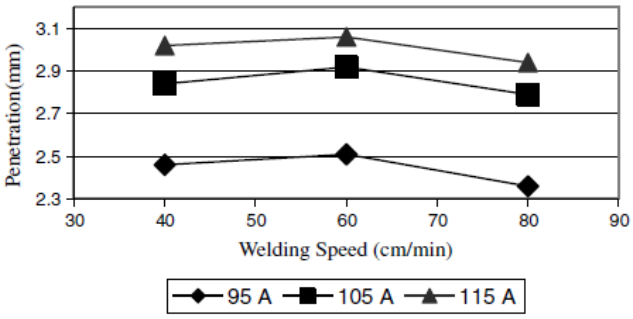


Fig. 7: Penetration vs welding speed graph for 22V arc voltage [1]

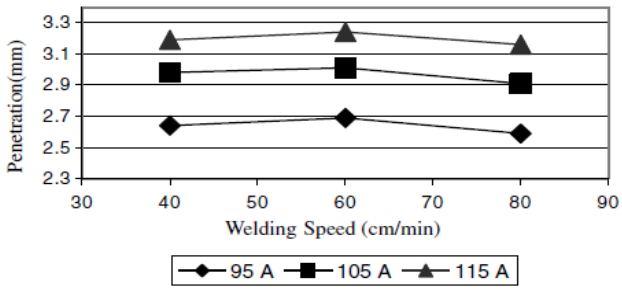


Fig. 8: Penetration vs welding speed graph for 24V arc voltage [1]

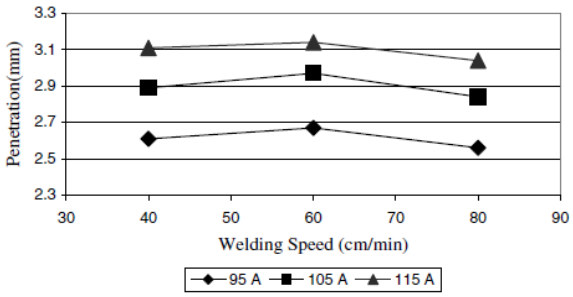


Fig. 9: Penetration vs welding speed graph for 28V arc voltage [1]

The above graphs suggest that as the welding speed increases, the depth of penetraion increases in all the three cases. However, the it decreases as the speed is increased beyond 60cm/min. this means that for any welding condition, there is a optimum value of welding speed, beyond which if the speed is increased, the depth of penetraion decreases.

V. SHEILDING GAS AS A CONTROLLING PARAMETER ON GAS METAL ARC WELDING

The primary function of sheilding gas used in welding process is to protect the molten metal pool from atmospheric nitrogen and oxygen. The gas also helps to maintain stable arc and uniform metal transfer. As the sheilding gas dominates the mode of metal transfer, the quality of weld highly depends on sheilding gas. The sheiding gas not only affects the properties of weld but also determines the shape and penetraion pattern. Hence it becomes necessary to study the effect of change in composition of sheilding gas on quality and penetration of weld. The test results of steel ST-37-2 (0.007% P, 0.01%S, 0.024%Si, 0.002% Ti, 0.417% Mn and 0.113% C) are presented to study the effect.[2]. The results are obtained for four different combinations of sheiding gases, which are as under:

a. S1 - 97.5% Ar + 2.5%CO_2
b. S2 - 90% Ar + 10%CO_2
c. S3 - 82% Ar +18%CO_2
d. S4 - 75% Ar + 25%CO_2

A. Effect of shielding gas on penetration

The effect of increasing CO_2 content in the shielding gas can be studied from following figures.

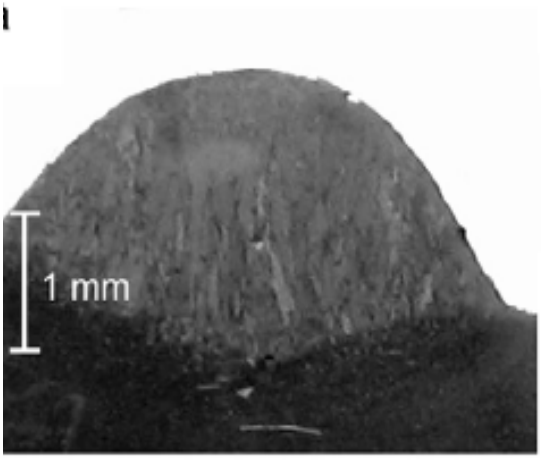


Fig. 10: Cross-section of weld pool for sample S1 (97.5% Ar + 2.5%CO_2) [2]

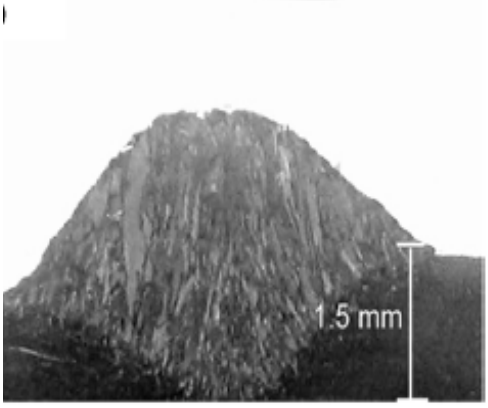


Fig. 11: Cross-section of weld pool for sample S1 (90% Ar + 10%CO_2) [2]

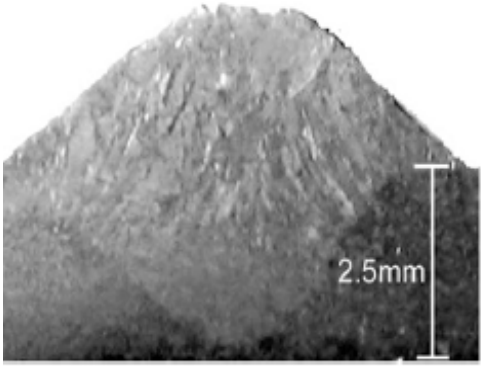


Fig. 12: Cross-section of weld pool for sample S3 (82% Ar + 18%CO_2) [2]

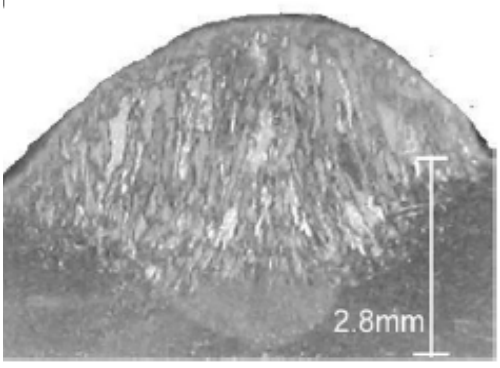


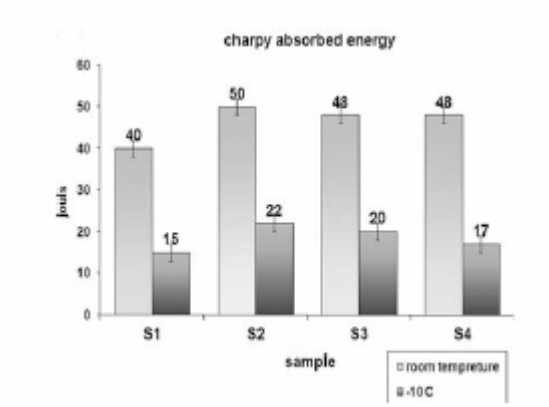
Fig. 13: Cross-section of weld pool for sample S4 (75% Ar + 25%CO_2) [2]

The above figures suggest that increase in carbon dioxide content increases the penetraion in the weld pool. (1.8 mm increase for 22.5% increase in carbon dioxide content

B. Effect of shielding gas on properties of weld:

1) Effect on toughness of the sample:

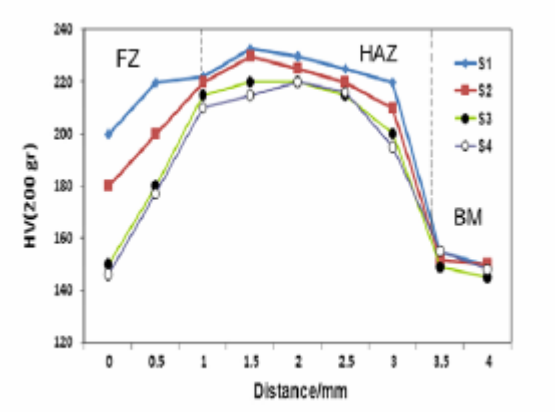
Test results of Charpy test conducted on samples is as follows:



The graph suggest that impact energy aborbed by the sample increases with increase in amount of carbon dioxide the toughness of samples increase until certain level, beyond which the value decreases. The cause for this is said to be change in microstucture of the sample.

2) Effect on hardness of the sample:

Hardness profiles of the samples along the cross-section of each sample is shown below:



It can be seen that weld metal hardness decreases with increase in amount of carbon dioxide in the sheilding gas. The reason attributed is decrease of acicular ferrite(AF) in the samples.

VI. CONCLUSIONS

In view of the results presented, the following points can be concluded:

- As the welding current increases, the depth of penetration increases. The increase is almost linear.
- Increase in arc voltage also increases the depth of penetration. However the increase in penetration is less compared to that of increase observed with increase in current
- Increase in welding speed increases depth of penetration. However beyond certain limit, i.e. optimum speed, further increase in speed causes decrease in penetration.
- Change in composition of sheilding gas causes a change in penetration and weld property. As presented in the paper, increase in carbon dioxide content increases the depth of penetration. However the toughness of the weld increases only until certain limit and hardness of the weld decreases.

VII. REFERENCES

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