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Influence of magnetically-assisted micro plasma arc welding process on penetration in austenitic stainless steel (SS-304) weldments

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Abstract
In this work, investigations on characteristics of weld of AISI stainless steel using DOE methodology with and without magnetic interaction in microplasma welding studied. Three welding parameters i.e. magnetic field strength, welding current and plasma gas flow rate used to conduct the experiment. The objective of this paper was to study the effect of magnetic field on the weld quality and geometry when the field is applied longitudinal to the electrode travel i.e. the field lines are perpendicular to the electrode travel. It was noticed from experimental results that with the interaction of magnetic field to the welding arc, penetration decreases.

Keywords: micro-PAW, weld bead, PGFR, penetration, magnetic field

1. Introduction
Austenitic stainless steel (SS-304) is most commonly used as a structural material have higher strength with excellent surface finish. Austenitic steel is mostly used for tooling and auto mobile parts namely as aero-engine, rocket parts of combustion area and having superb weldability and forming characteristics. SS-304 can be welded by using variety of welding process namely as Electron beam welding, TIG (Tungsten inert gas welding), LBW (Laser beam welding), PAW (Plasma arc welding) etc., [1-3]. Among these method Micro-PAW has concerned specific consideration for the fabrication of structural metal where high toughness is required. Non consumable tungsten electrode is used for generation of heat to join metals under gas shielded area [3, 4-6]. In this process variation of current is involves during welding cycle. Frequency of current alter the penetration of bead and minimum current is supply to generation stabile arc [7-10]. In this welding process heat generated by arc is effectively used to fuse the spot with required dimensions in fraction welding cycle. In this article the weld bead profile of SS-304 was investigated under the effect of external magnetic field in under laboratory testing condition. Experiment was carried by changing strength of magnetic field, current and PGFR during investigation. Taguchi L_9 array of analysis higher is better was used to optimize the experiment runs. In present work it was noticed that bead penetration can be controlled for fabrication thin plate by using magnetic field.

2. Material Specifications
The effect of external magnetic field was investigated by using austenitic stainless steel (SS-304) plate have size 3.2X75X100 mm. The chemical composition of SS-304 was determined by using by spectroscopy. Spectroscopy results shows that metals C, Cr, Mn and Ni was present 0.7, 18.4, 0.54 and 9.4 % (by weight) respectively. Details of chemical composition of SS-304 is tabulated in Table 1. The low carbon AISI SS-304L filler wire (diameter 1mm) was used as a filler material during welding process. The chemical composition of filter material is listed Table 1. During experiment Micro-PAW welding process with DCEN polarity was used. Argon gas mixed with CO_2 was used as plasma and shielding gas respectively during experimentation. Semi-automatic Micro-PAW welding was carried by shield gas was flow at rate of 8ltr/min with welding speed 260 mm/min by vertical position of welding torch.

Table 1: chemical composition of work piece and filler wire used in Micro-PAW

Element	C	Ni	Cr	Mn	S	P	Si	Fe
Work Piece (SS-304)	0.07	9.4	18.4	0.54	0.02	0.03	0.3	Balance
Filler Wire	0.03	9.8	19.2	0.63	0.03	0.04	0.7	Balance

3. Experimental Procedure
Most commonly solenoid coils is used for interaction of external magnetic field to arc [4-7]. In this process another power source is required so it is not suitable for large scale production. In present study investigated the magnetic control of arc plasma with permanent magnets that have recently become smaller in size and higher in intensity and, unlike solenoid coils, do not need another power source. Gaussmeter was used to measure the strength of applied magnetic field strength. The magnets were kept at predetermined with fixed distance apart from gaussmeter. Opposite poles of magnet are kept face to face (attracting mode) so that they attract each other, then only we get some values of magnetic field there. The distance of magnate from arc was optimized by trail runs. The trails results show that magnet at 2mm from arc put considerable magnetic effect on welding arc. The two magnet having of strength 176 and 255 Gauss was used in experiment. Design of experiment (DOE) was designed by using taguchi methods. Taguchi method is an efficient problem solving tool, which can improve the performance of the process with a

significant slash in experimental time and cost [10]. Taguchi developed an effective design of experiment technique, using the Orthogonal Arrays (OA). Taguchi method allows for the analysis of many different parameters without excessive amount of experimentation. For example, a process with 3 factors, each with 3 levels, would require 27 experiments to test all factors. L_9 analysis was used for study the penetration. The three variable with three level used for the investigation is shown in Table 2. Based on the above parameters & their levels, the following design matrix is prepared as per taguchi design methodology 3 factors at 3 levels = 27 runs. But only 9 runs are performed as per Taguchi's L_9 orthogonal array. The design matrix with L_9 used for the investigation is tabulated in Table 2. Welding speed is kept constant as only one welding speed is taken on automated welding table moving the workpiece which is shown below in figure. Specimen is kept on the automated table. The current and plasma gas flow rate range is set on the Micro-PAW machine and weld bead is deposited without interaction of magnetic fields. The similar setting is used in welding with magnetic field interaction same welding parameter used for without external magnetic field. Only change is that the permanent magnets are applied. Specimen was cut by using wire EDM process at J S Die Makers, Ludhiana to get specimen for polishing. Specimen was initial polished on polishing machine to clean the surface of metal at welding metallurgy lab, SLIET University.

Table 2: L_9Array of DOE matrix with response of variable parameter

Runs	Magnetic field (Gauss)	Current (Ampere)	PGFR (Ltr./min)	Penetration (mm)
1	0	28	0.3	0.461
2	0	29	0.4	0.772
3	0	30	0.5	1.376
4	176	28	0.4	0.939
5	176	29	0.5	1.268
6	176	30	0.3	0.324
7	255	28	0.5	0.897
8	255	29	0.3	0.222
9	255	30	0.4	0.423

4. Results and Discussion

Optical microscope was used to examine profile of weld bead with and without interaction of external magnetic which is shown in Fig. 1(a-d). From Fig. 1(a-b) it was shown that weld bead have higher penetration. Initial weld bead was polished by using series of emery paper set by set. The bead profile of the polished specimens were examine to measurements of penetration. The experimental results were tabulated in Table 2. The experimental results was used as response data namely as penetration for analysis by using Minitab 17. The means of response data helps to optimize the input parameter of experiments which is shown in Fig. 2. From Fig. 2 the data means of penetration is plotted on Y- axis and input factors magnetic field, current and PGFR are taken on X- axis. Fig. 2. shows that with increase of magnetic field, penetration decreases.

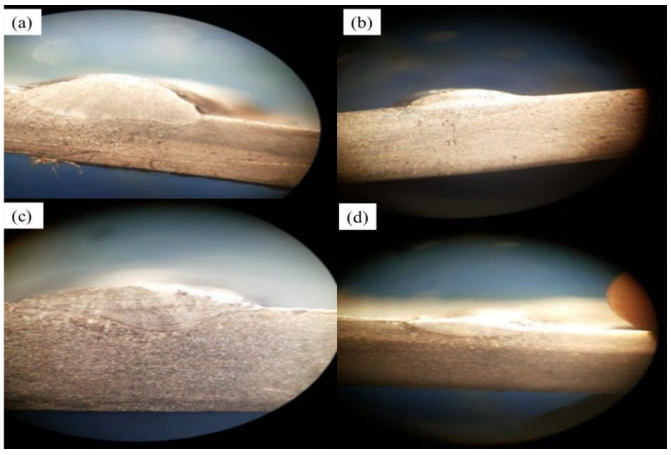

Fig 1: (a-b) Weld bead deposition without magnetic interaction; (c-d) weld bead deposition with magnetic interaction.

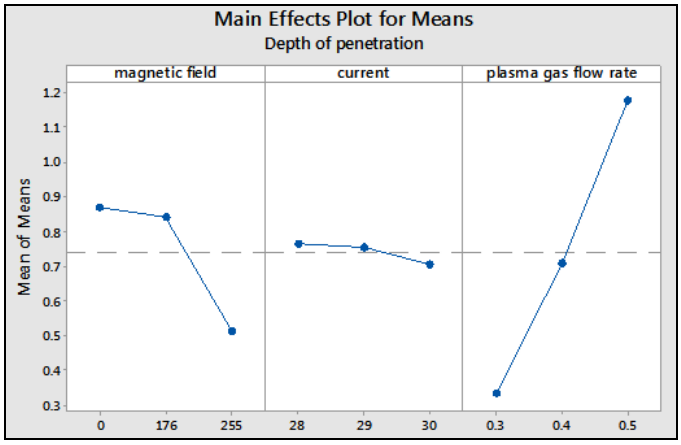

Fig 2: Main effects plot for data means of penetration

5. Conclusion

Following conclusion where drawn on bases of current investigation:

- DOE is effective to optimize the number of experiment and prediction of outcome with lower experimental cost.
- In Micro-PAW arc welding, with the interaction of magnetic field to the welding arc, depth of penetration decreases.

6. References

1. Balasubramanian M, Jayabalan V, Balasubramanian V, Acta Metall. Sin. (Engl. Lett.). 2010; 23(4):312-320.
2. Balasubramanian B, Jayabalan V, Balasubramanian V. J Mater. Sci. Technol. 2006; 22(6):821-825.
3. Singh RP, Gupta RC, Sarkar SC. Int. J Appl. Inn. Engg. Manag. 2012; 1:2319-4847.

4. Prasad KS, Rao CS, Rao DN. Int. J Adv. Manuf. Techno. 2015; 78:625-632.
5. Senapati A, Mohanty SB. Int. J Engg. Trend. Techno. 2014; 10(6):297-303.
6. Curiel FF, Garcia R, Lopez VH, Sanchez JG. J Jap. Inst. Metal. 2012; 52:1701-1704.
7. Dar YA, Singh C, Farooq Y. Ind. J Appl. Res. 2014; 4:2249-555X.
8. Tovar RS, Montanes MT, Anton JG. J Corro. Sci. 2011; 53:2598-2610.
9. Becker KH, Kersten H, Hopwood J, Lopez JL. Europ. Phy. J. 2010; 60:437-439.
10. Singh G, Kumar S, Mohapatra SK. Material. Today. Proc. 2017; 4:3565-3571.