Experimental Study of Pulsed Current Gas Tungsten Arc Welding & Development of Parameters for Fillet Welding of DP28W Tubes Using Slope Equation Function

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Abstract— In this experimental work tests were conducted on the fillet weldments of DP28W using GTAW with pulsed current on Tubes. The aim of this experimental work is to aid development of parameters for Pulsed Current GTAW using slope equations, see the effect of pulsed current on the characteristics of weldments, and to compare the heat input between pulsed and non-pulsed GTAW. The experimental results pertaining to different welding parameters for the above material using pulsed current and non-pulsed GTAW are discussed.

Keywords: DP28W, Pulsed current welding, Gas Tungsten Arc Welding, heat input.

I. INTRODUCTION

Duplex Stainless Steel components are highly in demand for high quality processes, which need materials with high corrosion resistance such as urea strippers and boilers. Duplex Stainless steel can be welded easily by method of Gas Tungsten Arc Welding (GTAW). GTAW is more suitable than other processes as it provides best quality welds. Direct Current Straight Polarity (DCSP) is preferred for welding Duplex Stainless Steel. The most recent development is that of pulsed current GTAW.

Development of pulsed current welding provided with many advantages such as reduced heat input from the welding process, greater penetration depth, lower HAZ range, reduced defects such as lack of fusion, porosities and cracks. It is ideal for joining pressure parts, with the certain degree of automation.

Experimental analysis of pulsed current GTAW was carried out previously to obtain grain refinement, improving mechanical properties of Weldment; however, the main aim of this paper is to verify its suitability in industrial application of the process to weld DP28W components.

II. EXPERIMENTAL PROCEDURE

The workpiece for the experiment was to be provided with a fillet weld. The workpiece was provided with a V' profile Weld Edge which was formed by two mating pipes which provided a 90^o internal angle. The Entire assembly was held in a chuck at 45^o angle, so that the specimens could be welded with pulsed and non-pulsed current in the GTAW process in 1F position as per the ASME code.

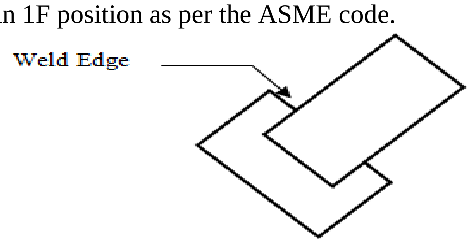

Fig.1: Weld edge preparation

The weld edges were cleaned both using acetone and a SS wire brush wheel on a portable grinder.

The experiment was carried out using a "Fronius" GTAW power source with DC output, working in programmed cycle with a PLC programmed lathe machine so as to impart the necessary rotary motion to the workpiece, with the necessary travel speed of welding. The torch assembly is mounted on a ball screw arrangement with an encoder motor so as to enable Automatic Voltage Controller Programming, which will maintain arc length during welding. The torch utilizes longitudinally ground 2.4mm diameter "Throated Tungsten" (EWTh2) electrode with 30^o tip angle so as to ensure maximum penetration.

The power source provides a square pulsed DC current with programmable characteristics for initial current, upslope, down slope and crater current so as not to cause defects such as end crater cracking.

The cycle can be represented by the following graph.

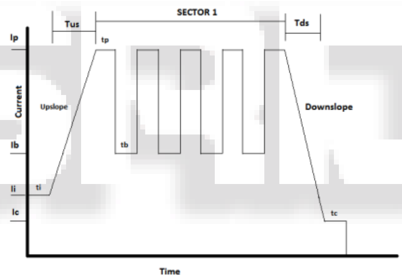

Fig 2: Pulsing cycle

T_i: Time Initial/Start Current I_i: Initial Current

T_{us}: Time Upslope Current I_p: Peak Current

T_p: Time Peak Current I_B: Background Current

T_b: Time Background current I_C: Crater Current

T_{ds}: Time Downslope Current

T_c: Time Crater/End Current

The filler wire used for the welding process is a WELTIG 28W filler wire in spool form, fed into the arc by means of an automated wire feeder under the PLC control.

The chemical composition of the material is as shown in the table below.

Table.1: Alloying Elements in Base Metal

Alloyant	Percentage
C	≤0.03
Si	≤0.05
Mn	≤1.1
P	≤0.03
S	≤0.01
Ni	7.0-8.2
Cr	27-27.9

Mo	0.8-1.2
N	0.3-0.4
W	2.1-2.5

The chemical composition of the filler wire is having matching composition with that of the base material.

The weld parameters were developed utilizing a simple trend line equation obtained by a graphical representation of the various trials conducted on the tubes. Nearly 20 trials were carried out, following which, a graph was plotted for the varying parameters of current i.e. Initial current, Peak current and Background current against Voltage as the experiment was performed on a Constant Voltage Setting.

The following graphs represent the values of Initial Current, Peak Current and Background current vs. Voltage.

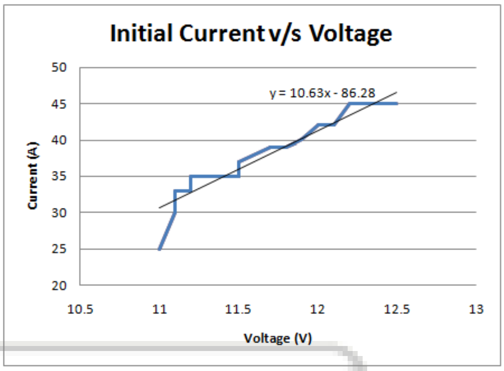

Fig. 3: I_C vs. Voltage

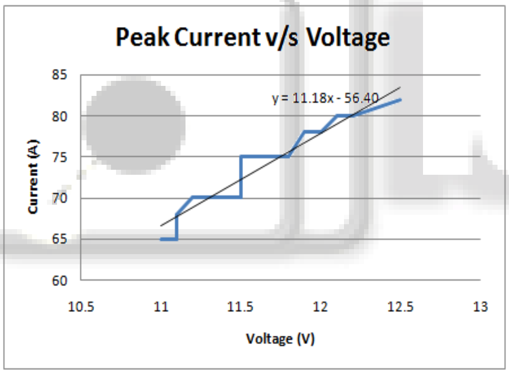

Fig. 4: I_P vs. Voltage

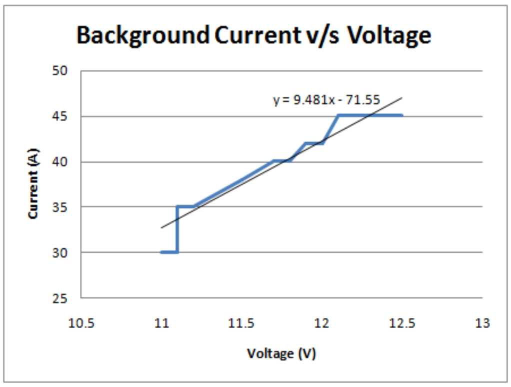

Fig. 5: I_B vs. Voltage

As it is seen from the graph, the slope equations for the graphs of Initial Current, Peak Current & Background v/s Voltage are as follows:

$$y = 10.63x - 86.28$$
$$y = 11.18x - 56.4$$
$$y = 9.481x - 71.55$$

As per the ASME section IX code, for a peak welding current of ≤100A, the voltage should be around 11-13 volts. Considering the arc stability at 12.5V, the above equations yield the ideal welding current parameters.

Hence if V = x = 12.5, then,

Initial Current = 46.59 = 47A

Peak Current = 83.35 = 83A

Background Current = 46.96 = 47A

Utilizing these parameters, a successful trial for the pulsed current GTAW process was yielded. The same parameters of peak current and travel speed were used to weld a non pulsed current specimen.

Table. 2: Welding Parameters for Pulsed current GTAW

Initial Current (A)	Peak Pulsing Current (A)	Background Pulsing Current (A)	Arc Voltage (V)
47	83	47	12.5

III. WELD METAL TESTING AND HEAT INPUT ANALYSIS

The samples welded were tested by Macrographic Technique to determine any defects in the weldment.

The Macrographic Results of the samples were found to be acceptable as they did not contain any visible cracks, porosities or Lack of Fusion as per the Section IX of the ASME code. The non pulsed current specimen showed a slight Lack of Fusion in the corner of the Weld Edge.

Fig 6: Pulsed Current GTAW Macro

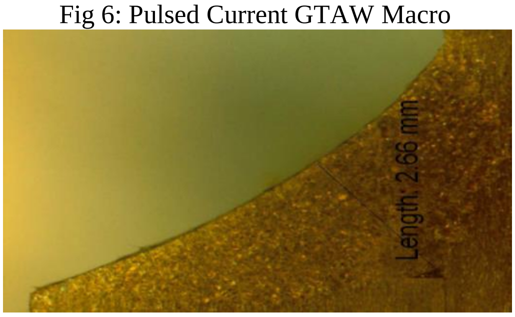

Fig. 7: Non pulsed Current GTAW Macro

The Ferrite content of the sample was tested as it is essential to maintain ferrite content in Duplex Stainless Steels. It was found to be acceptable in the welded specimen.

Table. 3: Ferrite Analysis

Process	Ferrite content required	Ferrite content obtained
Pulsed GTAW	40-80%	50%
Non Pulsed GTAW	40-80%	45%

The seam was segregated as per the timing and length for peak pulsing current and background pulsing current during the entire welding cycle. The travel speed was maintained at 7.25cm/min. The values are as shown below.

Table. 4: Heat Input in Pulsed Current GTAW

Stage	Current (A)	Voltage (V)	Weld Length (mm)	Heat Input (KJ/mm)
Peak	83	12.5	52.4	0.85
Background	47	12.5	26.2	0.48

The heat input for the Non-pulsed GTAW process was as found in the table below.

Table. 5: Heat Input in Non-Pulsed current GTAW

Stage	Current (A)	Voltage (V)	Weld Time (s)	Weld Length (mm)	Heat Input (KJ/mm)
Non Pulsed GTAW	83	12.5	65	78.6	0.85

Table. 6: Heat Input Comparison between Pulsed and Non-Pulsed Current GTAW

Stage	Pulsed Current GTAW	Non-Pulsed Current GTAW
Peak Pulse Heat Input (KJ/mm)	0.85	0.83
Background Pulse Heat Input (KJ/mm)	0.48	--
Weld Length Peak Pulse (mm)	52.4	78.6
Weld Length Background Pulse (mm)	26.2	--
Total Heat Input in Seam (KJ)	57.68	67.43

As seen from the table above, the heat input in Non-Pulsed current GTAW process in greater than in Pulsed current GTAW. Hence, reduced heat input is desirable as it leads to higher impact value, and lesser chances of failure in weldments.

IV. CONCLUSIONS

This experimental work is aimed to check the feasibility for a pulsed GTAW welding setup for DP28W material for commercial purpose. Macroscopic testing reveals greater acceptance for pulsed current weldment due to elimination of possible defects. Furthermore, pulsed current GTAW shows advantage over Non-pulsed current GTAW in terms of reduced Heat-Input in the welding process.

The slope Equations provide a nearly proper and simple parameter setting for welding, thereby eliminating errors and need for extensive trials.

REFERENCES

[1] Eiki Nagashima, Yoshiro Ideguchi, Yutaka Kita, Yoshimi Yamadera, "New Duplex Stainless Steel DP28W^{TM}Contributes to Safe and Reliable Operation of Urea Plant", Ammonia Technical Manual, 2004.
[2] Jun-Ichi Higuchi and Eiki Nagashima, "Development of DP28W^{TM} Duplex Stainless Steel", Stainless Steel World, June 2009.
[3] Dr. J. Charles, "Duplex Stainless Steels, A Review after DSS '07 held in GRADO".
[4] Richard Campbell, "Avoiding Defects in Stainless Steel Welds", Welding Journal, May 2007.
[5] Raveendra and Dr. B.V.R. Ravikumar, " Experimental Study on pulsed and Non pulsed current TIG welding of stainless steel sheet (SS304)", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 2, Issue 6, June 2013.
[6] Raveendra and Dr. B.V.R. Ravikumar, " Effect of Pulsed Current on Welding Characteristics of EN19 Alloy Steel using Gas Tungsten Arc Welding", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 2, Issue 5, May 2013.
[7] Indira Rani M. and R. N. Marpu, "Effect of pulsed current TIG welding Parameters on Mechanical properties of J-Joint strength of AA6351", The International Journal of Engineering and Sciences, Volume 1, Issue 1, November 2012.
[8] H. R. Saedi and W. Unkel, "Arc and weld Pool behavior for Pulsed current GTAW", AWS Welding Research Supplement, November 1988.
[9] E. Farahani, M. Shamanian and F. Ashrafizadeh, "A comparative study of direct and pulsed current GTAW of alloy 617", AMAE International Journal on Manufacturing and Material Science, Vol. 2, No. 1, May 2012.
[10] ASME Section IX and ASME Section II-C

