Effect of Pulsed Current on the Mechanical Property of Weldment of Pure (AA1900) Aluminium

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Abstract— Pulsed Gas Tungusten Arc Welding (GTAW-P) combines the low spatter level of spray transfer with the low heat input of globuler and short circuit transfer. The main drawback of GTAW-P is the large number of paraxmeter s that must be adjusted to produce a stable arc. Synergic control with programmed ability has made the application of complicated pulse wave-forms simple and easier. These all characteristics are very suitable for the welding of pure aluminium (99.95% purity) because the refractory oxide film which is difficult to avoid insoluble in the metal and infers with the wetting action of molten filler metals. GTAW-P power source can remove these difficulties by selecting suitable high peak current and low background current. Here high peak current timing indicates the melting time of the electrode and background current time indicates the heat dissipation and solidification time. So, this concentrated heat input can burn the oxide layer and remove the difficulties produced by it. This also indicates the easiness of welding in upward position, with uneven root gap and also for low thickness we don't have the problem like burn through. The effect of the pulsed parameters on the weldment shall be evaluated by taking peak current, background current, frequency and pulse ratio as variable parameters and rest are taken as constant. Total 26 readings will be taken and on the basis of this the mechanical properties will be found out .Now on the basis of this results optimized parameter will be concluded by Taghuchi method that will be incorporated by MINITAB software and will be proven experimentally Finally the superiority of pulsed welding will be proven by taking the readings for the same welding condition but under the continuous welding.

Key words: Pulsed Current, GTAW-P, GMAW, TIG, Taguchi Method, ODDP, WPT

I. INTRODUCTION

Pulsed power source is a modified version of TIG welding, in which the welding current (DC or AC) is fed intermittently in the form of pulses. The pulsed current alternates between a low or background level and a high or peak level. The duration and amplitude of both peak and background can be varied independently to suit the job. The melting takes place during the peak current period, and the weld pool solidifies between pulses as the heat is dissipated in the job during the background current period. This current pulsing leads to intermittent melting along the joint seam, giving a series of discrete melt spots which overlap each other.

The most significant feature of this process is the apparent tolerance to external variables such as joint geometry, clamping, fit-up, dissimilar thicknesses or other factors causing variation in thermal heat sink This tolerance is derived from the fact that the weld pool is allowed solidify during background time, and owing to this the effect of heat build-up is largely overcome.

There are following advantages of Pulsed Power Source:

1. (1) Excellent oxide cleaning is obtained because of the strong positive half cycle.
2. (2) Higher currents can be used with a given size electrode because the positive half cycle that heats the electrode can be of less duration.
3. (3) Deeper penetration than with the balanced wave because penetration occurs during the negative half cycle. Adjusting the balance control to provide an increase in the negative half cycle will accomplish this.

II. PERFORMANCE ANALYSIS

Yu Wing Chan [1] explained a model has been developed to predict the thermal history of a pulsed current gas tungsten arc welding system. The model was tested using low carbon steel specimen. A good correlation was found between the predicted results and the experimental results. The non-linear heat transfer finite element program adopted has been shown to be able to predict temperature fields and temperature time profile during the course of the welding operation. The areas near the beginning and the end of the weld are subjected to non-stationary temperature changes. The solidification rate in the weld pool and cooling rate in the heat-affected zone are expected to be a lot higher in the non-stationary state than in the quasi-stationat3~ st~e. The model ling and the solutions of non-stationary welding heat flow in the work presented arc satisfactory.

P. Praveen et al [2] explained that recent developments in the controlled transfer have achieved better control of GMAW-P and offer benefits in both production and quality. The use of intelligent microprocessor control in conjunction with automatic feedback control systems can provide implementation of quality systems at affordable price. With advent of technology and increase in the knowledge base about welding processes, future trend of GMAW-P machines is likely to be improved performance at affordable price.

P.K. Palani, N. Murugan [3] explained that Effect of pulse parameters on weld qualities and various approaches adopted by researchers to select these parameters were reviewed in detail.

Several researchers have reported that, achieving ODPP is a complex process, requiring a lot of trial and error experimentation and the process of determining the parameters that will provide ODPP with a droplet diameter approximately equal to the wire diameter is very time consuming and complicated. Although ODPP is usually considered to be the ideal in GMAW-P, some authors have reported that, good quality welds can be made under conditions of more than one droplet per pulse also. Of the pulse parameters, peak current and peak duration, plays a dominant role in determining the weld bead properties. Burn-off rate, droplet detachment and arc stability have been the primary criteria for selecting the parameters for pulsed gas metal arc welding. Most of the researchers had not taken the effect of base current while selecting the parameters, to characterize the feasible parametric zone. Though some researchers reported that, the effect of background condition is significant in modeling the ODPP; other researchers asserted that, the background condition had no significant effect. Different authors had adopted different approaches to determine the wire feed speed and they had indicated that the wire feed rate depended on the wire materials composition, size of wire and electrode extension. Only a very few had used design of experiments to carry out their experiments for selecting the pulse parameters and to study their effect on weld metal properties.It has been reported by some authors, that, the dynamic response (dl/dt), of the power source also affects the pulse parameter selection. The fusion rate is remarkably influenced by the dynamic characteristics and smaller droplets had been observed for faster dynamic response.

Chiung-Hsin Tsai et al [4] explained that the weld root pass is a major determinant of the welding quality, and the width of root pass is usually used as indication of full penetration. In this research, an automatic pulsed GTAW system with fuzzy controller and real-time visual image feedback was proposed for pipes welding. The root pass width is used as the control target and feedback signal in the GTAW system and the width of weld root pass is measured by applying edge detection technique to the weld image captured from CCD camera. The rules of fuzzy controller are developed from previous knowledge and experience of welding In the experiment results show that this fuzzy pulsed GTAW system can automatically adjust the weld mean current in real time and achieve well welding quality. The experiments have been implemented successfully to weld pipes with various welding position.

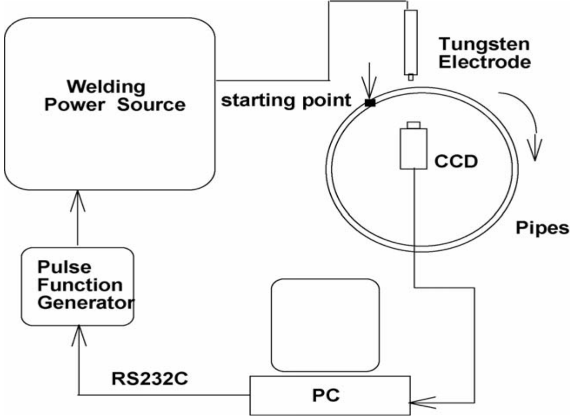

Fig. 1: Process diagram of an automatic orbital GTAwelding of pipes with CCD visual feedback setup[4].

Gaofeng Fu et al [5] explained that The HAZ of the 7005 alloys can be divided into two subzones according to their different mechanism of softening the dissolution zone and the overageing zone. The dissolution zone is characterized by dissolution of precipitates and covers the peak temperature range above 380 ◦ C. The overageing zone is characterized by growth of precipitates and covers the peak temperature range between 230 and 380 ◦ C.HAZ hardness can be recovered by post-weld heat treatment. Artificial ageing is more effective than natural ageing considering the recovery of the hardness.

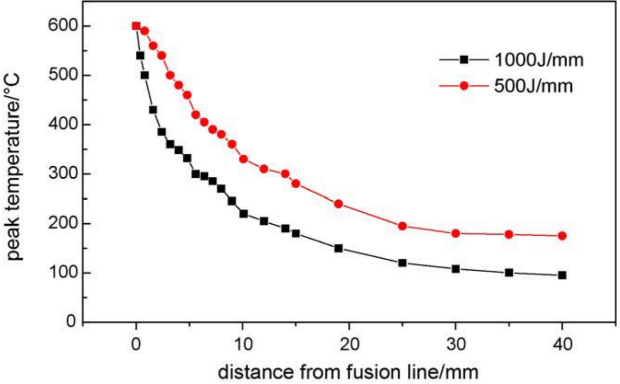

Fig. 2: The relation between peak temperature and the distance from the fusion boundary for two heat inputs (500 and 1000 J/mm) [5].

P.K. Ghosh et al[6] explained that In pulsed current GMAW the arc root diameter and its projection can be controlled by changing the factor φ and Im at a given arc voltage especially at the level lower than about 20–21 V using 1.6 mm diameter Al–Mg filler wire. The increase of arc voltage up to about 25 V predominantly enhances the arc length (L) almost linearly in spite of certain amount of influence of φ and Im on it. Accordingly the arc extinguishes (L = 0) at a voltage below about 14 V. At a given arc voltage and Im the increase of φ up to about 0.4 significantly enhances the L whereas, at a given φ of 0.05 the increase of Im considerably reduces the same linearly showing that the arc extinguishes at about 426 A primarily due to high wire feed rate. At relatively large pulse off time (tb) the arc stability and its characteristics are primarily governed by the base current where φ and Im plays an insignificant role. But, at a relatively low Ib below about 92 A the φ significantly influences the arc stability. The stability in shielding of arc environment is primarily a function of arc length and arc stiffness where the welding at a relatively lower arc voltage below about 22 V and appropriately matching higher current beyond about 122 A and a suitable [Ib /Ip] ratio may be beneficial. In case of multiple drop transfer per pulse the metal transfer from Al–Mg filler wire during the peak current takes place with heterogeneous nature in lump as well as with fragmentation or transfer in relatively smaller droplets. A long duration of high base current along with large φ of the order of 0.4 may cause metal transfer also at the pulse off period. The average droplet diameter transferred per pulse predominantly reduces by the increase of IP and the measured values are well in agreement to their corresponding theoretically estimated values. The pulse parameters Im and φ also appreciably influence the droplet diameter due to their correlation with IP. The increase of current primarily enhances the velocity of metal transfer at the time of detachment where the Im and φ play insignificant role in it keeping the measured velocities in close approximation to their estimated values. The velocity of metal drops transferred at a given welding parameter shows certain extent of heterogeneity. The measured velocity of metal drop at the time of deposition also shows agreement to its estimated one. The velocity of plasma may have significant influence on enhancement of the velocity of metal drop within the arc environment.

V.K. Goyal et all[6] explained that An appropriate consideration of a combined heat source accompanying the general concept of the point and distributed heat sources gives rise to development of an analytical model for estimation of temperature distribution in weld pool of pulsed current GMAW process operating at different pulse parameters. The significant agreement of the model predicted temperatures of Al–Mg alloy and commercial aluminium at different locations of their weld pool and HAZ with the experimental results justifies the capability of the proposed model to predict the temperature of the weld pool with reasonable accuracy in the region beyond 2 mm away from the heat source. The model can also effectively predict the penetration and width of fusion of the base plate and consequently the geometry of the weld pool of the aluminium and its alloy especially at high mean currents at or beyond the transition current of the globular to spray transfer of the filler wires. The computed results are fairly useful, however the present model can be further precisely calibrated by selecting more appropriate heat source parameters using the computed and experimental data in order to predict the temperature of the weld pool as well as its HAZ with improved accuracy. However, the application of the model with an accuracy of ±10% is limited to prediction of the weld pool temperature at depth beyond 2 mm from its surface and the weld geometry at mean current above 150 A.

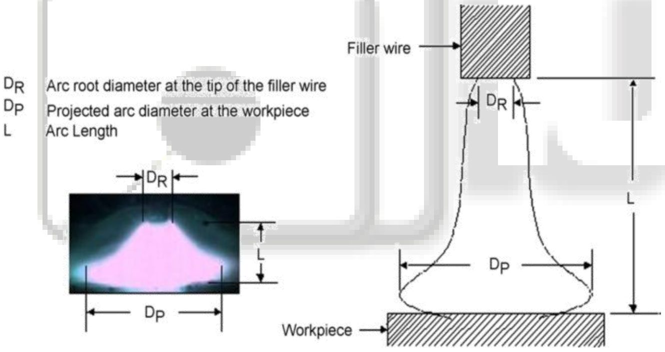

Fig. 3: Schematic diagram showing measurement technique of arc characteristics [6].

Zhifen Zhang et al[7] explained that This paper proposed a method for on-line defect detection for aluminium alloy in pulsed GTAW based on the statistical feature of The emission lines of ArII and ArI in SOI-7 (584.95–608.41 nm) have the great correlation with the seam oxidation, while the emission lines of MnI and MgI in SOI-1 (387.16–409.88 nm) are influenced by the defect of arc crater. The intensity of ArII in SOI-3 (477.36–491.73 nm) is affected and severely increases when the welding current transfers from base to peak causing the instant expanding of plasma arc. The feature parameters D and K of SOI-1, 5, 7 and 8 have showed the better sensitivity to the seam oxidation than the parameter R. The parameter K is more sensitive following with more noise and less steady, while D is quiet stable in most cases. By using the Wavelet Packet Transform (WPT) with optimal Coif4 Wavelet function and five decomposition levels, the pulse interference has been successfully removed, and reconstructed signals also display the certain sensitivity to the defect in frequency bands of 1.5625–3.125 Hz and 4.6875–6.25 Hz

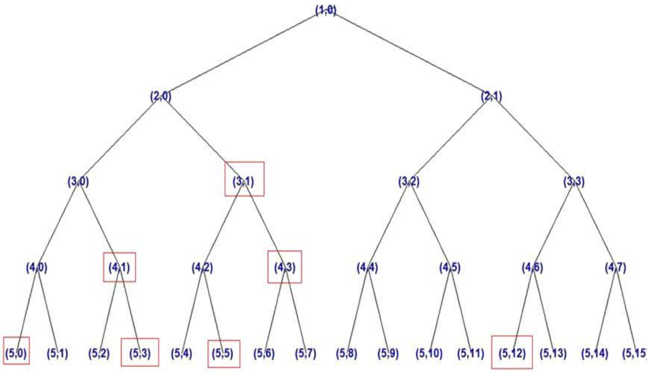

Fig. 4: Part of the WPD tree with decomposition level of 5[7].

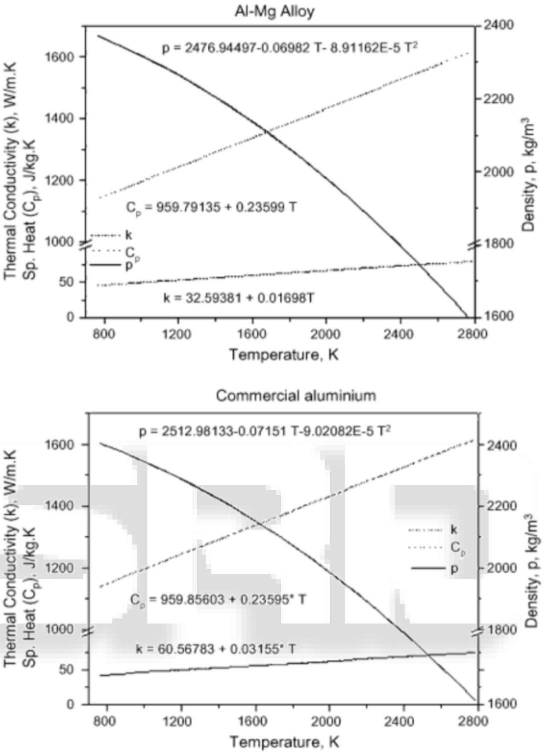

Fig. 5(a): Temperature-dependent thermo-physical properties of molten metal of Al–Mg alloy. b)Temperature dependent thermo-physical properties of molten metal of commercial aluminium.

Nabeel Arif, Hyun Chung [8] explained that the metal transfer in the AC-GMAW process was analyzed, and a comprehensive model was proposed for predicting the metal transfer in free-flight modes of DC-GMAW, P-GMAW, and AC-GMAW the following are the key results and conclusions of the study. arc cross-section, Drop sizes, which control the key gap-bridging ability of the process, were predicted and compared with the corresponding experimental data for different wires of steel and aluminum alloys. Discrepancy in prediction increased at high EN ratios owing to the unavailability of appropriate wire melting constants for the pulsed EN region for steel wire. Reasonable results were achieved in the ODOP range; however, the proposed model has a limitation in predicting the metal transfer in the MDOP and MPOD modes of P- and AC GMAW. In the welding of thin sheets with varying gaps, the model can also be used for the prediction of required parameters in real time and updating them to the welding power supply.

Rakesh Kumar et al [9] he explained by changing the EN ratio the depth of penetration can be controlled, increasing the EN ratio results in shallow penetration, which resulted in excellent welds of thin sheets.2. Use of AC wave pulse welding gave high quality appearance to bead shape, which is preferred especially for aluminum welding. Weld porosity was less than 1% and same was attributed to change of electrode polarity, causing easy escaping of absorbed gases. 4. Mechanical properties of thin sheet welds were quite good. Tensile strength of 6082 alloy welds was more than 200 MPa and % age elongation more than 2%.

A. Kumar, S. Sundarrajan [10] The influence of pulsed welding parameters such as peak current, base current, welding speed, and frequency on mechanical properties such as ultimate tensile strength (UTS), yield strength, percent elongation and hardness of AA 5456 Aluminium alloy weldment have been studied and the following conclusions are obtained. The same optimum combination (i.e. P2B1S2F2) is observed in all the mechanical properties of welds. The behaviour of the welded joints at the optimum condition (i.e. P2B1S2F2) of process parameters is attributed to increase an amount of Mg2Al3 precipitates that are formed in the aluminium matrix. In addition, the metallographic analysis reveals a fine grain structure at the weld centre, which results in higher mechanical properties. It is observed that, there is 10–15% improvement in mechanical properties after planishing. This is due to fact that, internal stresses are relieved or redistributed in the weld. Regression equations were developed to predict the quality characteristics, i.e. ultimate tensile strength, yield strength, percent elongation, and hardness within the selected range of parameters. The practical benefit this study is that, with use of obtained optimum condition increases the mechanical properties and developed regression models are useful for the automation of the process.

S. BABU et al [11] 1) The predominant pulsed current parameters of GTA welded AA6061 aluminium alloy such as peak current, base current, pulse frequency and pulse on time are optimized by using Hooke and Jeeves algorithm, to attain the maximum tensile strength and minimum fusion zone grain size. However, the validity of the procedure is limited to the range of parameters considered for investigation. Design of experiment concept and Hooke and Jeeves Pattern Search method are more economical to predict the effects of pulsed current parameters on tensile strength and grain size by conducting an optimum number of experiments. A minimum fusion zone grain diameter of 19.89 μm is obtained at a peak current of 171.25 A, base current of 84 A, pulse frequency of 3.5 Hz and pulse on time about 48.5% using the optimization procedure and it closely matches with the experimentally determined results.4) Response graphs and contour plots are drawn to study the interaction effect of pulsed current GTA welding parameters on tensile strength and fusion zone grain size of AA6061 aluminium alloy.5) The differences in responses of confirmation tests are due to the influences of the uncontrollable factors such as heat conduction, heat input variation and hysteric losses, which can be controlled

III. CONCLUSION

Here by pulsed welding we can get not only the best quality of welding particularly for aluminum but also the speed can be enhanced. Here we can also get the automized welding of GTAW for the material like aluminium. So, with regards to quality and productivity of thin section material this method is optimum

IV. ACKNOWLEDGEMENT

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REFERENCES

[1] Yiu Wing Chang,"Computer simulation of heat flow in pulsed current arc welding",Journal of material processing Technology, 38(1993) 449-464 Elsevier.
[2] P. Praveen et al,"Advancements in pulse gas metal arc welding", Journal of Materials Processing Technology 164–165 (2005) 1113–1119.
[3] P.K. Palani , N. Murugan, "Selection of parameters of pulsed current gas metal arc welding", Journal of Materials Processing Technology 172 (2006) 1–10
[4] Chiung-Hsin Tsai et al "Fuzzy control of pulsed GTA welds by using real-time root bead image feedback", Journal of Materials Processing Technology 176 (2006) 158–167
[5] Gaofeng Fu et al, "Studies on softening of heat-affected zone of pulsed-current GMA welded Al–Zn–Mg alloy", Journal of Materials Processing Technology 180 (2006) 216–220.
[6] P.K. Ghosh et al, "Analytical studies on thermal behaviour and geometry of weld pool in pulsed current gas metal arc welding", journal of materials processing technology 2 0 9 (2 0 0 9) 1318–1336.
[7] Zhifen Zhang et al, "Real-time defect detection in pulsed GTAW of Al alloys through on-line spectroscopy", Journal of Materials Processing Technology 213 (2013) 1146– 1156
[8] Nabeel Arif Hyun Chung, "Alternating current-gas metal arc welding for application to thin sheets", Journal of Materials Processing Technology
[9] Rakesh Kumar et al, "Thin sheet welding of Al 6082 alloy by AC pulse-GMA and AC wave pulse-GMA welding", Materials and Design 30 (2009) 306–313
[10] A. Kumar, S. Sundarrajan, "Optimization of pulsed TIG welding process parameters on mechanical properties of AA 5456 Aluminum alloy weldments", Materials and Design 30 (2009) 1288–1297.
[11] S. BABU et al "Optimizing pulsed current gas tungsten arc welding parameters of AA6061 aluminium alloy using Hooke and Jeeves algorithm", Trans. Nonferrous Met.Soc. China 18(2008) 1028-1036.