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Effect of Increase of Electrode Diameter on Creating Possibility of TIG Soldering Speed in Aluminum Alloy to Steel Connection

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Abstract: *According to this matter that the connection of diverse metals such as AL 5A06 with 660° melting point and steel SU 321 with 1385° melting point with different thermal features like the expansion coefficient and conductivity for the connection in the fusion welding conditions causes the creation of internal pressure after the welding. Then, the connection of these two kinds of metal, despite its necessity and specific application by the fusing method, would be resulted in considerable breakdown and impairments; so, the method of soldering (arc welding) was applied with inert Argon-based shielding and with Pulse TIG machine with developed technology and application of cover of plating Zn on SU 321 and producing the galvanized steel on the steel SU 321 and for the reason of increase of the speed of soldering operations The soldering operations and current intensity, low diameter of the electrode were not suitable for high soldering speed and current strength. So, the electrode diameter is necessarily increased according to the increase of current intensity; then, it can be said that the electrode diameter is a factor effective on providing the condition for creating the TIG soldering speed in the connection of AL 5A06 and SU 321.*
Taxonomy:
Galvanization: cover of aluminum on steel, AL 5A06: aluminum alloy
Expansion coefficient: coefficient of extensiveness, pulse: pulsed
Connection: the place welded, SU 321: stainless steel.

Keywords: *Electrode Diameter, Tig, Aluminum, Steel Connection*

INTRODUCTION

The necessity of the connection of similar and diverse metals to each other has been of observable subjects of today and has special status among the industries; and always many efforts have been made to achieve the technology of metals connection. Among different kinds of connections, the special attention has been paid to the weld connections because of their resistance and the product of these efforts is the variety of welding (Hosford & Caddell, 1983). Among different welding methods with developed technology, special attention has been paid to the connection of diverse metals by welding in the industries specially the industries of aerospace and projectile, and the industries of topography in making the very exact digital cameras and the exhaust manifold and connecting the cylinder- head to the leg of injectors and dynamo and dashboard; and for this purpose, it was decided to weld the diverse metal of aluminum to the galvanized steel because of different reasons such as different melt temperature and expansion coefficient and high wettability at melt temperature of AL in soldering operations by the welding Pulse TIG machines (Moeinian 1st volume, 2006;

Moeinian 3rd volume, 2006). With regard to the literature review of research, many studies was done in 2009 by the researchers of this industry like J.L.S, C.B.L, C.L.F, S.B.A, J.L, G.C, and L.Y; and these studies were carried out in regard of the connection of two diverse metals Aluminum Alloy and galvanized Steel by the use of Pulse TIG machines with different features such as " connection of two diverse metals in different conditions", "suitable wettability of galvanized matter", "expansion of cable of welding the liquid aluminum on the surfaces of steel", " increase of efficiency and application of inert Argon in this soldering and protection of proper mechanical features of the matters in different conditions of speed of welding operations" ; that in this welding, the most important parameters such as the increase of gas flow rate are considerable (Moeinian second volume, 2006). The gas flow rate is one of the most effective factors in the protection of connection quality at high speed and because, in literature review of the research, this kind of connection has been studied in the operations with high speed; so, this parameter was studied in this research due to its effect on the speed of operations of diverse metals connection (Muthupandi et al., 2003; Pollack, 1988).

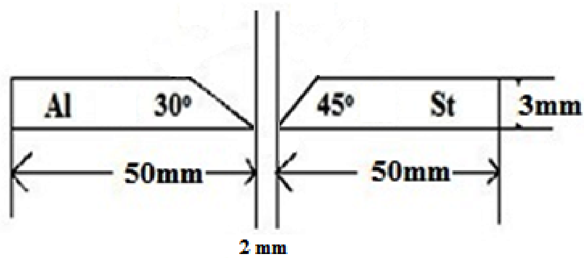

Figure 1: Manner of preparation of segments for welding

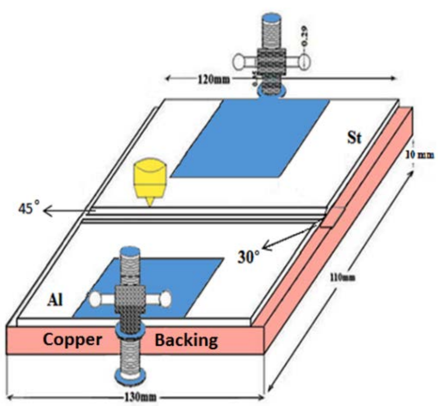

Figure 2: Manner of preparation of fixed segments for welding

Table 1: Features of TIG welding machine- Model 200PARSTIG AC/DC 200

200	Current maximum with lowest work factor
5- 200	Current welding of DC ampere
5- 200	Current welding of AC ampere
200	Current welding with work factor of %35
120	Current welding with work factor of %60
85	Amount of DC voltage
70	Amount of AC voltage
Current balance, manual phase of low amplitude of gas	Modulation
HF	Ignition system
Sinuous- form	Wavy forms

Figure 3: Look of segment of SU 321 tested for the analysis of chemical compound

Table 2: Result of testing the tensile of segment of SU 321 for evaluating its resistance

Row	Thickness*width A*B (mm*mm)	Cross- sectional area S_0 (mm^2)	Resistance proof of offset R_t 0.2% Mpa	Final resistance of R_m Mpa	Elongation
1	12.58*2.97	37.36	382	609	47
Uncertainty of U_E= +/-3%					
Standard permissible limit					

Table 3: Results of analysis of chemical compound of SU 321 sheet (weight percent)

C	Si	Mn	P	S	Cr	Mo	Ni	Al	Co	Cu
0.033	0.57	1.21	0.015	<0.003	17.1	0.09	9.1	0.019	0.01	1.09
Nb	Ti	V	W	Fe						
0.017	0.38	0.10	<0.02	Base						

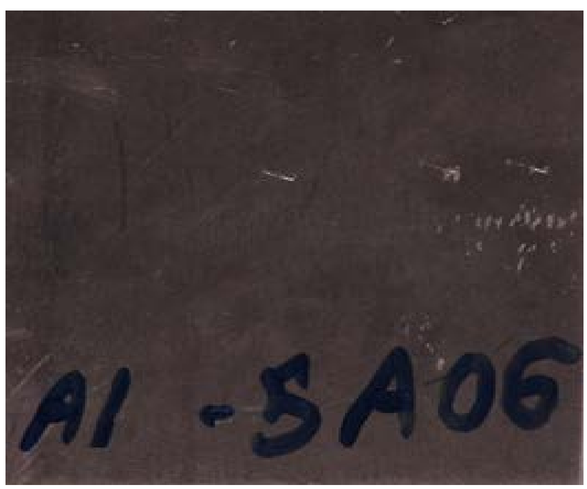

Figure 4: Look of segment of untested Al-5106

Table 4: Results of testing the tensile of segment of Al-5A06 for evaluating its resistance

row	Thickness*width A*B (mm*mm)	Cross- sectional area S_o (mm^2)	Resistance proof of offset R_t 0.2% Mpa	Final resistance of R_m Mpa	Elongation
1	12.55*3.0	36.65	146	311	24.5
Uncertainty of U_E= +/-3%					
Standard permissible limit					

Table 5: Results of analysis of chemical compound of Al 5A06 plate (weight percent)

Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ti	Be	Ca	Li
0.16	0.29	0.06	0.8	4.25	0.08	0.02	0.03	0.033	Trace	Trace	Trace
Pb	Sn	Sr	V	Na	Bi	Co	Zr	B	Gx	Cd	Al
0.01	<0.005	Trace	0.013	Trace	0.002	0.003	Trace	0.003	0.003	0.004	Base

Table 6: Comparison of compounds of segments and filler

row	materials	Al percent	Fe percent	Si percent	Zn percent	Explanation
1	Al 5a06	Base	0.29	0.16	0.03	The mount of mentioned percent of aluminum exists in the segment.
2	SU 321	0.019	Base	0.57	-	The aluminum with galvanized cover or No Clock Flux is provided.
3	Al Si 4047	Rem	0.35	0.3-0.6	<0.05	The mount of mentioned percent of aluminum exists in the segment.

Table 7: Electrode diameter at different welding speeds

Soldering speed (s)	80mm/s	100mm/s	120mm/s	165mm/s
Electrode diameter	1.6 mm	1.6 mm	2.4 mm	2.4 mm

Procedure

In the connection of these two diverse metals, a segment of stainless steel SU 321with dimensions of 120mm×50mm×3mm and slat angle of 45° and melting point of 1385° and a segment of Aluminum Alloy with dimensions of 120mm×50mm×3mm in the slat angle of 30° and melting point of 660° and a filler of Al Si 4047 with different diameters of 2mm and 3mm were selected and after plating the stainless steel by the use of Zn and its galvanization for the purpose of assimilating the melting point of steel with the one of Aluminum alloy and providing the condition for the connection and (copper- fastener with dimensions of 130mm×110×10mm and with slope angle of 120mm×8mm×0.5mm for controlling the segments temperature) and with a fixture equipped with two plate fixatives and the tractor including the torch equipped with the speed control systems; and the safety equipment such as crash helmet, gloves, shoes, and specific clothes were prepared. Then, the welding operation was done by the use of inert argon gas with a nozzle with different diameters for the protection of quality of soldering and the Pulse TIG AC- DC – Model 200 Pars welding machine with different speeds were provided for evaluating the possibility of soldering operations with further speed and efficiency; and after machining the welded segments, for doing the tensile and microhardness test operations, the Imstron4208 tensile and Bohler micromet11 microhardness testers were applied respectively for testing the tensile and microhardness of the welded segments (Zandi, 2008).

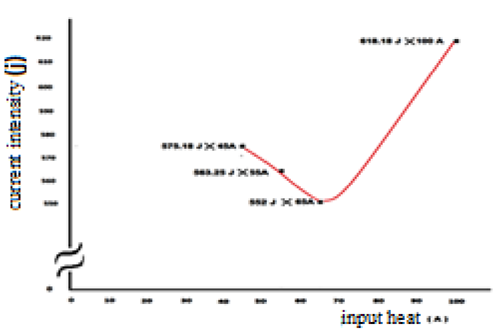

Figure 5: Chart of input heat at different welding speeds

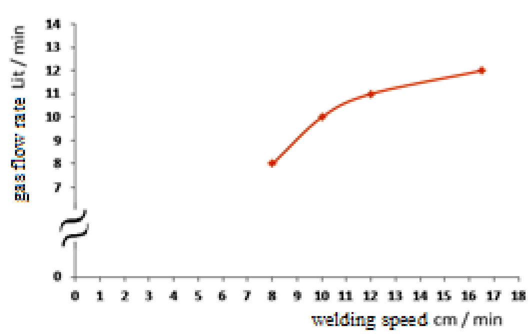

Figure 6: Chart of gas flow rate at different welding speeds

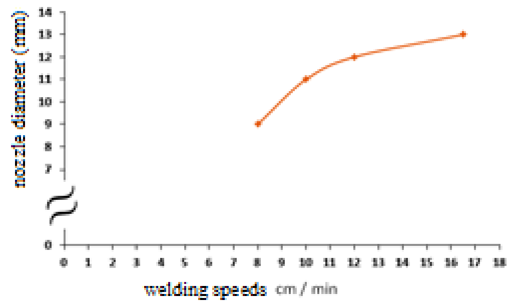

Figure 7: Chart of nozzle diameter at different welding speeds

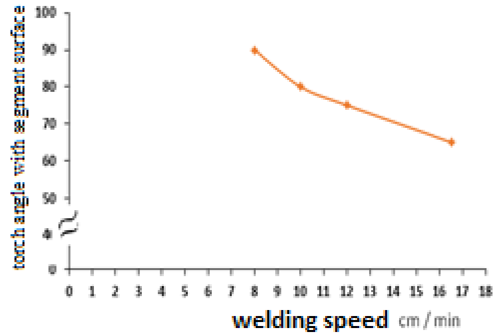

Figure 8: Chart of torch angle with segment surface at different

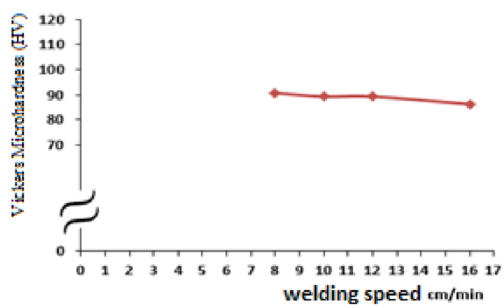

Figure 9: Effect of welding speed on microhardness of connection

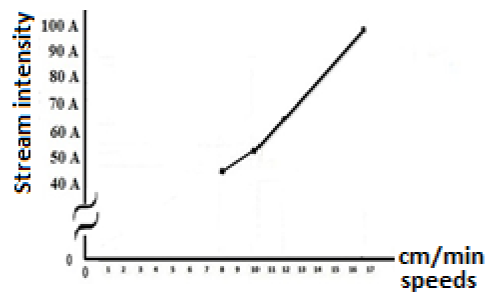

Figure 10: Chart of increase of current intensity with different speeds

Figure 11: Segment welded from the head with speed of 8 current intensity of 45A and filler of 2mm

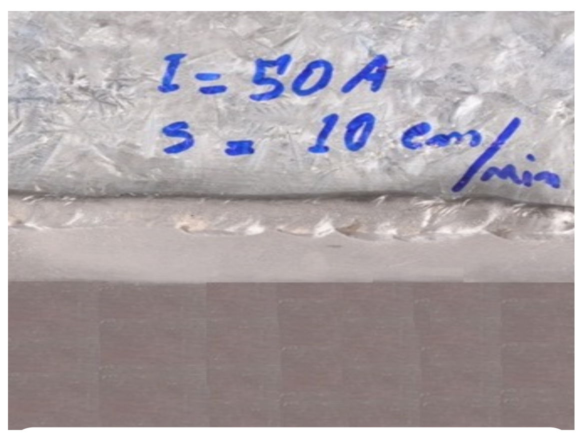

Figure 12: Segment welded from the head with speed of cm/min, 10cm/min, current intensity of 55A and filler of 2mm

3 mr

Figure 13: Segment welded from the head with with speed of 16.5cm/min, current intensity of 3mm 100A and filler of 3mm

Figure 14: Segment welded from the head speed of 12cm/min, current intensity of 65A and filler

Figure 15: Sample of tensile testing of segments with regard to the standard ASTM E8M (2011)

Figure 16: Upper look of segment with speed of 8cm/min prepared before tensile test

Figure 17: Upper look of segment with speed of 10 cm/min prepared before tensile test

Figure 18: Upper look of segment with speed of 12 cm/min prepared before tensile test

Figure 19: Upper look of segment with speed of 16 cm/min prepared before tensile test

Figure 20: Upper and lower look of segment with speed of 8cm/min prepared after tensile test

Figure 21: Upper and lower look of segment with speed of 10 cm/min prepared after tensile test

Figure 22: Upper and lower look of segment with speed of 12 cm/min prepared after tensile test

Figure 23: Upper and lower look of segment with speed of 16 cm/min prepared after tensile test

Table 8: Results of tensile test with speed of (8 cm/min)

Row	Thickness*width A*B (mm*mm)	Cross- sectional area S_0 (mm^2)	Resistance proof of offset R_t 0.2% Mpa	Final resistance of R_m Mpa	Place of incidence of break
1	6.11×3.0	18.33	124	150	WM (Weld Metal)

Table 9: Results of tensile test with speed of (10 cm/min)

Row	Thickness*width A*B (mm*mm)	Cross- sectional area S_0 (mm^2)	Resistance proof of offset R_t 0.2% Mpa	Final resistance of R_m Mpa	Place of incidence of break
1	6.07×3.0	18.21	122	143	WM (Weld Metal)

Table 10: Results of tensile test with speed of (12 cm/min)

Row	Thickness*width A*B (mm*mm)	Cross- sectional area S_0 (mm^2)	Resistance proof of offset R_t 0.2% Mpa	Final resistance of R_m Mpa	Place of incidence of break
1	6.45×3.0	19.35	120	136	WM (Weld Metal)

Table 11: Results of tensile test with speed of (16.5cm/min)

Row	Thickness*width A*B (mm*mm)	Cross- sectional area S_0 (mm^2)	Resistance proof of offset R_t 0.2% Mpa	Final resistance of R_m Mpa	Place of incidence of break
1	5.69 ×3.0	17.07	118	129	WM (Weld Metal)

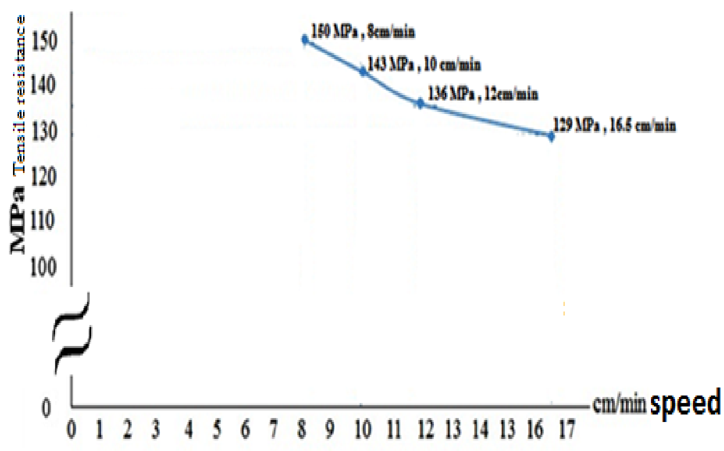

Figure 24: Effect of welding speed on final resistance of connection

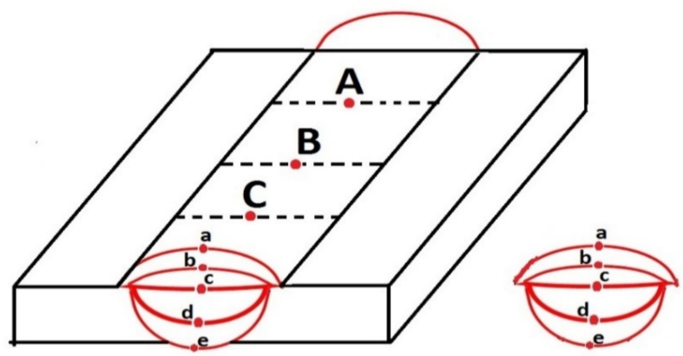

Figure 25: Samples selected for microhardness testing from different weld points

Figure 26: Mounted sample of microhardness testing

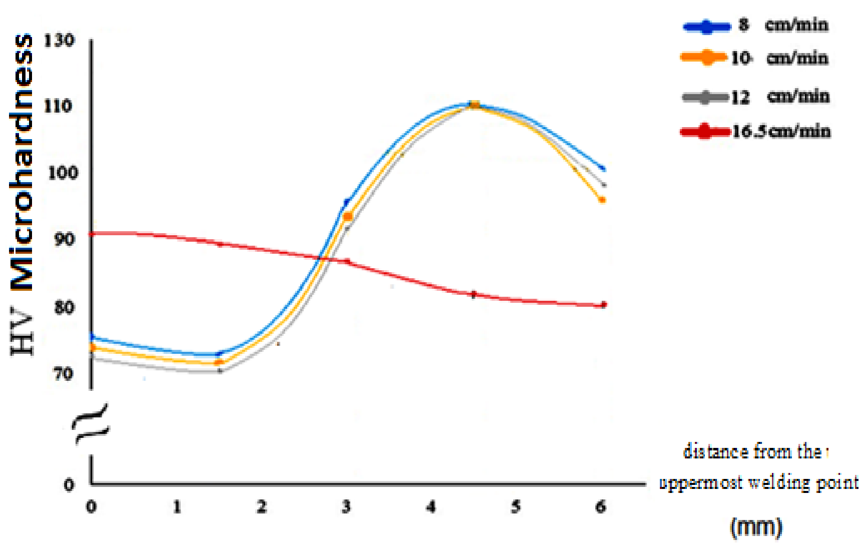

Figure 27: Chart of amount of microhardness at welding points with different speeds

Discussion and conclusion

Because the amount of Zn in the segment of Al 5A06 was 0.030% and in the filler of Al Si 4047 was <0.05; but it did not exist in SU 321 segment and for this reason, the melting point of steel is more than the one of AL and their connection is possible only by depressing the melting point of steel by its galvanization. So, by plating Zn on the steel, it was galvanized and by assimilating the melting point of two segments and the use of inert argon gas for the protection of welding quality, the AL 5A05 and SU 321 were connected by the use of welding machine that was most suitable for this connection (Pulse TIG). To access to the further efficiency and output rate, the speed of welding operations was changed from 80mm/s to 165mm/s That this affair is for the reason of reduction of the heat entered into the lower surfaces of weld pool and also the reduction of tiny fines and the tensile resistance of the connection. For solving this problem, the proper increasing current intensity was applied that was an effective factor in the input heat and also the formation of tiny fines in the weld pool; and for the reason of high soldering speed and current intensity and the inefficiency of low electrode diameter in that, we necessarily increase the electrode diameter, that was an effective factor in melting the filler, from 1.6 mm to 2.4 mm at high speeds

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