iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** III **Month of publication:** March 2021

DOI: https://doi.org/10.22214/ijraset.2021.33184

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue III Mar 2021- Available at www.ijraset.com

Evaluating Bending Strength of Future Structural Material in Automobile Industries: Al-SiC composite Weldment during different Variants of TIG Welding such as ATIG, PCTIG & PCATIG Welding

Sivachidambaram Pichumani[1], Raghuraman Srinivasan[2], Venkatraman Ramamoorthy[3].
[1]PhD Research Scholar, [2, 3]Professor, School of Mechanical Engineering, SASTRA University, Thanjavur, India – 613401.

Abstract: In TIG welding of Al-SiC composites, reduced mechanical properties and lesser weld penetrations are the commonly observed problems. To overcome these challenges, Activated TIG (A-TIG) welding and pulsed current TIG (PCTIG) welding techniques are being used. PCATIG welding is a combination of ATIG and PCTIG welding process. This approach of combined mode of welding has the advantage of increased weld penetration and improved bending strength. Comparing the CCTIG, ATIG, PCTIG and PCATIG welding conditions, the following results are observed. ATIG with SiO_2 as flux (ATIG-SiO_2) and ATIG with TiO_2 as flux (ATIG-TiO_2) show positive effect of increased bending strength. The conditions ATIG-CaO, ATIG-MgO and ATIG-MnO_2 shows slight improvements with slight sacrifice in bending strength than the normal CCTIG welding. It is also observed that the usage of Al_2O_3 as active flux coating in ATIG welding results in reduced bending strength. During PCATIG welding on Al-8%SiC composite, PCATIG welding shows improved bending strength than the normal ATIG welding process. Hence PCATIG welding with both SiO_2 and TiO_2 shows improvement in bending strength than the other welding conditions.
Keywords: ATIG welding; PCATIG welding; Al-SiC composite; Bending strength.

I. INTRODUCTION

Aluminium is extensively used as a metal matrix material because of its ease in processing with SiC, TiB_2, TiC and B_4C reinforcements on aluminium metal matrix [1]. Aluminium metal matrix is well known for its good wear resistant and higher strength to weight ratio [2]. Aluminium silicon carbide composite (Al-SiC) shows improved strength & stiffness to the weight ratio. It can also retain these properties in elevated temperatures than the base material [3]. Stir casting facilitates for higher production rate than other manufacturing process. Stir casting is possible by minor modifications in conventional casting process [4]. Stir casting used for manufacturing of Al-SiC composite shows more suitable and economical way compared to other manufacturing processes such as powder metallurgy route [5] and spray coating process [6].

Gas Tungsten Arc Welding (GTAW) also known as Tungsten Inert Gas (TIG) welding shows high quality welds when compared with other arc welding process. Non ferrous metals requires the quality weld with reduced defects and improved mechanical properties of the weld for which TIG welding is more suitable approach of welding of even thin sections. However, its shallow weld penetration requires more number weld passes which in turn leads to lesser production rate [7].

Welding of Al-SiC composite using TIG welding shows poor weld mechanical properties. This is due to higher heat input in Al-SiC, leading to SiC dissociation and forming (Aluminium Carbide) Al_4C_3 + (Silicon) Si. Al_4C_3 phase which is brittle in nature [8]. This results in considerable loss in weld strength and ductility. Restricting aluminium carbide formation during TIG welding on Al-SiC composite improves strength and ductility [9]. To restrict the aluminium carbide formation lesser heat input is needed during TIG welding.

In order to reduce the heat input into weld, Activated TIG welding (ATIG) a new variant was developed in early 1960's by the Paton Welding Institute, Ukraine which improves the weld penetration [10]. In this ATIG welding many variants are found of which adding fine layer of active flux is one of the most widely used method. Here active fluxes like chlorides [11], titanium oxides [12], fluorides [13], silicon oxides [14], calcium oxides [15], magnesium oxides [16] and sulfur [17] are commonly used.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue III Mar 2021- Available at www.ijraset.com

The above surface active element is coated on the plate before normal TIG welding for the creation of the new variant ATIG welding. Addition of active elements like oxygen, carbon di oxide along with shielding gas of argon [18] and helium [19], tends to increase in weld penetration. This ATIG welding doubles the weld penetration than the normal TIG welding along with reduction in heat input and increased production rate [20]. Coating of active flux before welding gains more popularity than active shielding gas mixture due to its ease of application in the existing system and more cost effective.

The activated flux TIG welding follows two types of mechanisms which are mostly accepted, first one is based on the reverse Marangoni convection effect, and the other one is based on arc construction effect.

Pulsed current TIG (PCTIG) welding shows improved weld properties [21] through grain refinement in weld zone microstructure from coarse grain structure to fine grain structure [22]. PCTIG also reduces the width of the heat affected zone & thermally induced stresses through increasing cooling rate of the weld zone & reduced the heat input compared to TIG welding leading to improvement in tensile properties [23] and fatigue behavior [24]. This pulsed current TIG welding reduce the formation of aluminium carbide which in turn increases the weld properties of Al-SiC composite.

Intensive work has been done with ATIG on stainless steel alloys and few studies have been carried out on non ferrous metals such as magnesium, titanium, aluminium and nickel alloys. So investigation of weld strength of Al-SiC composite with ATIG shows significant importance in the manufacturer of aluminium composites. An attempt has been made by combining the pulsed current TIG and activated TIG welding (PC-A-TIG) on Al-SiC composite for getting superior weld properties with improved weld penetration.

II. EXPERIMENTAL PROCEDURE.

Autogenous welding has been performed on Al-8%SiC composite material with a plate dimension 100 x 100 x 5 mm using ADOR CHAMPTIG 300AD welding machine. The welding parameters considered during welding are provided in table 1. Different active fluxes of Al_2O_3, CaO, MgO, SiO_2, TiO_2, MnO_2 are coated before welding process to perform ATIG and PCATIG welding variants.

Table 1: Welding parameter during CCTIG, PCTIG, ATIG and PCATIG welding

Parameter	Condition
Current Type	AC Current
Electrode Diameter	3.2 mm
Electrode Material	2% Th - Tungsten Electrode
Arc Length	2 mm
Arc Voltage	18V
Welding Speed	2 mm/s
Argon Flow Rate	18 l/min
Active Layer Coating	0.5-1 mg/cm^2
Heat Input	990 J/mm
Constant Current TIG	110 A
Peak Current	160A
Base Current	60A
Pulse On Time	50%
Pulse Frequency	5Hz

Pulsed current TIG welding parameters are optimized [25] and compared with constant current TIG welding. Here in both the CCTIG and PCTIG welding constant heat input is maintained. Bend test is performed using a special bend test attachment in Universal Testing Machine with the standard of ASTM E190 on the specimens with dimensions of 100mm x 30mm x 5mm (L x W x T) in Figure 1. Sample before and after bend test are shown in figure 2 and figure 3 respectively.

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue III Mar 2021- Available at www.ijraset.com

Figure 1: Attachments for bend test in UTM

Figure 2: Samples before bend test

Figure 3: Samples after bend test

III. RESULTS AND DISCUSSION

Table 2: Results – Bending Strength

Description	Bending strength (KN)
CCTIG	0.91
ATIG -Al_2O_3	0.79
ATIG -CaO	0.66
ATIG -MgO	0.59
ATIG -SiO_2	0.99
ATIG -TiO_2	0.82
ATIG -MnO_2	0.56
PCTIG	1.5
PCATIG -Al_2O_3	1.2
PCATIG - CaO	1.19
PCATIG -MgO	1.21
PCATIG -SiO_2	1.48
PCATIG -TiO_2	1.37
PCATIG -MnO_2	1.12

Table 2 shows the bending strength value of different variants of TIG welding processes. ATIG welding, CCTIG and ATIG-SiO_2, shows higher bending strength of 0.91KN & 0.99 KN. Other variants of ATIG-TiO_2 and ATIG-Al_2O_3 have intermediate value in the range of 0.79KN to 0.82KN. ATIG-CaO, ATIG-MgO and ATIG-MnO_2 show lesser bending strength ranging from 0.5KN - 0.6KN.

In PCATIG welding, PCTIG shows the highest bending strength of 1.5KN followed by PCATIG-SiO_2 of 1.48KN. Other PCATIG welding variants has 1.1KN - 1.4KN as their bending strength.

It is inferred that higher the bending strength shows higher ductility and toughness of the weld. Bending test is performed as face bend test since, the face of the weld having higher micro hardness value than the root of the weld.

IV. CONCLUSION

From the above study it is clear that active flux coating of CaO, MgO, SiO_2, TiO_2, Al_2O_3 & MnO_2 on TIG & PCTIG welding have significant influence on bending strength. In ATIG welding SiO_2 and TiO_2 have positive effect of increase in bending strength. Fluxes such as CaO, MgO, MnO_2 & Al_2O_3 shows slight reduction in bending strength than the normal CCTIG welding. PCATIG welding shows improved bending strength and weld penetration than the normal ATIG welding while using same active flux. In PCATIG welding, active fluxes of SiO_2 and TiO_2 shows improved bending strength than the ATIG welding, PCTIG welding and CCTIG welding conditions. Combination of PCTIG welding with ATIG welding results in advantages of improved bending strength through pulsed current TIG welding parameters and increased weld penetration by reverse Marangonic effect & arc constriction effect in ATIG welding.

V. ACKNOWLEDGEMENTS

The authors convey their sincere thanks with gratitude to The Vice Chancellor of SASTRA University, Thanjavur, India for pursing this research work by providing the facility in the School of Mechanical Engineering.

REFERENCES

[1] K.M. Shorowordi, T. Laoui, A.S.M.A. Haseeb, J.P. Celis, L. Froyen, (2003), Microstructure and interface characteristics of B_4C, SiC and Al_2O_3 reinforced Al matrix composites - a comparative study, Journal of Materials Processing Technology, 142, page 738-743. (doi:10.1016/S0924-0136(03)00815-X)
[2] Ahmed M. El-Sabbagh, Mohamed Soliman, Mohamed A. Taha, Heniz Palkowski, (2013), Effect of rolling and heat treatment on tensile behaviour of wrought Al-SiC_p Composite prepared by stir-casting, Journal of Materials Processing Technology, 213, page 1669-1681. (http:/dx.doi.org/10.1016/j.jmatprotec.2013.04.013)
[3] A. El-Sabbagh, M. Soliman, M. Taha, H. Palkowski, (2012), Hot rolling behaviour of stir-cast Al 6061 and Al 6082 alloys - SiC fine particulates reinforced composites, Journal of Materials Processing Technology, 212, page 497-508. (doi:10.1016/j.jmatprotec.2011.10.16)
[4] G.G. Sozhamannan, S. Balasivanandha Prabu, V.S.K. Venkatagalapathy, (2012), Effect of Processing Parameters on Metal Matrix Composites: Stir Casting Process, Journal of Surface Engineered Materials and Advanced Technology, Volume 2, page 11-15. (doi:10.4236/jsemat.2012.21002)
[5] Sajjad Amirkhanlou, Roohollah Jamaatri, Behzad Niroumand, Mohammad Reza Toroghinejad, (2011), Using ARB process as a solution for dilemma of Si and SiC_p distribution in cast Al-Si/SiC_p Composites, Journal of Materials Processing Technology, 211, page 1159-1165. (doi:10.1016/j.jmatprotec.2011.01.019)
[6] J. Hashim, L. Looney, M.S.J. Hashmi, Metal matrix composites: Production by the stir casting method, (1999), Journal of Materials Processing Technology, Volume 92-93, page 1-7. (PII: S0924 - 0136(9 9)00118 - 1)
[7] LEI Yu-cheng, YUAN Wei-jin, CHEN Xi-zhang, ZHU Fei, CHENG Xiao-nong, (2007), In-situ weld-alloying plasma arc welding of SiC_p/Al MMC, Transactions of Nonferrous Metals Society of China, 17, page 313-317.
[8] A. Urena, M.D. Escalera, L. Gil, (2000), Influence of interface reactions on fracture mechanisms in TIG arc-welded aluminium matrix composites, Composites Science and Technology, 60, page 613-622. (PII: S0266-3538(99)00168-2)
[9] V. Balasubramanian, V. Ravisankar, G. Madhusudhan Reddy, (2008), Effect of pulsed current welding on fatigue behaviour of high strength aluminium alloy joints, Materials and Design, 19, page 492-500. (doi:10.1016/j.matdes.2006.12.015)
[10] S. Leconte, P. Paillard, J. Saindrenan, (2006), Effect of fluxes containing oxides on tungsten inert gas welding process, Volume 11, Number 1, Science and Technology of Welding and Joining, page 43-47.
[11] R.-I. Hsieh, Y.-T. Pan, H.-Y. Liou, (1999), The Study of Minor Elements and Shielding Gas on Penetration in TIG Welding of Type 304 Stainless Steel, Journal of Materials Engineering and Performance, 8(1), page 68-74.
[12] Z.D. Zhang, L.M. Liu, Y. Shen, L. Wang, (2008), Mechanical properties and microstructure of magnesium alloy gas tungsten arc welded with cadmium chloride flux, Material Characterization, 59, page 40-46.
[13] Ding FAN, Ruihua ZHANG, Yufen Gu, Masao USHIO, (2001), Effect of Flux on A-TIG Welding of Mild Steels, Transaction of JWRI, 30, 1, page 35-40.
[14] Hidetoshi Fujii, Toyoyuki Sato, Shanping Lu, Kiyoshi Nogi, (2008), Development of an advanced A-TIG (AA-TIG) welding method by control of Marangoni convection, Material Science and Engineering A, 495, page 296-303. (Doi: 10.1016/j.msea.2007.10.116)
[15] Shanping LU, Dianzhong LI, Hidetoshi Fujii, Kiyoshi Nogi, (2007), Time Dependant Weld Shape in Ar-O_2 Shielded Stationary GTA Welding, Journal of Material Science and Technology, 23 (5), page 650-654.
[16] Shanping Lu, Hidetoshi Fujii, Kiyoshi Nogi, (2004), Marangoni convection and weld shape variations in Ar-O_2 and Ar-CO_2 shielded GTA welding, Material Science and Engineering A, 380, page 290-297. (Doi: 10.1016/j.msea.2004.05.057)

[17] Shanping Lu, Hidetoshi Fujii, Kiyoshi Nogi, (2008), Marangoni convection and weld shape variations in He-CO_2 shielded gas tungsten arc welding on SUS304 stainless steel, Journal of Material Science, 43, page 4583-4591. (Doi: 10.1007/s10853-008-2681-3)

[18] Shanping Lu, Hidetoshi Fujii, Kiyoshi Nogi, (2010), Weld Shape variation and Electrode Oxidation Behavior under Ar-(Ar-CO2) Double Shielded GTA Welding, Journal of Material Science and Technology, 26 (2), page 170-176.

[19] A. Berthier, P. Paillard, M. Carin, S. Pellerin, F. Valensi, (2012), TIG and A-TIG welding experimental investigations and comparison with simulation Part-2 - arc constriction and arc temperature, Volume 17, Number 8, Science and Technology of Welding and Joining, page 616-621.

[20] Kuang-Hung Tseng, Chih-Yu Hsu, (2011), Performance of activated TIG process in austenitic stainless steel welds, Journal of Materials Processing Technology, Volume 211, page 503-512.

[21] V. Balasubramanian, V. Ravisankar, G. Madhusudhan Reddy, (2007), Effect of pulsed current and post weld aging treatment on tensile properties of argon arc welded high strength aluminium alloys, Material Science and Engineering A, 459, page 19-34. (doi:10.1016/j.msea.2006.12.125)

[22] K. Karunakaran, V. Balasubramanian, (2011), Effect of pulsed current on temperature distribution, weld bead profiles and characteristics of gas tungsten arc welded aluminum alloy joints, Transactions of Nonferrous Metals Society of China, 21, page 278-286. (doi: 10.1016/S1003-6326(11)60710-3)

[23] V. Balasubramanian, V. Ravisankar, G. Madhusudhan Reddy, (2008), Effect of pulsed current welding on mechanical properties of high strength aluminum alloy, International Journal of Advanced Manufacturing Technology, 36, page 254-262. (doi:10.1007/s00170-006-0848-0)

[24] Selvi Dev, A. Archibald Stuart, R.C. Ravi Dev Kumaar, B.S. Murty, K. Prasad Rao, (2007), Effect of scandium additions on microstructure and mechanical properties of Al-Zn-Mg alloy welds, Materials Science and Engineering A, 467, page 132-138. (doi:10.1016/j.msea.2007.02.080)

[25] Sivachidambaram Pichumani, Balachandar Krishnamoorthy, (2015), Optimization of pulsed current TIG welding parameters on Al-SiC metal matrix composite – an empirical approach, Indian Journal of Science and Technology, Vol 8 (23), IPL0288, page 1-7.