iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 Issue: VI Month of publication: June 2023

DOI: https://doi.org/10.22214/ijraset.2023.53793

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VI Jun 2023- Available at www.ijraset.com

Latest Developments in TIG Welding - A Review

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Abstract: TIG welding has been used to join two metals or alloys by continuously providing a wire electrode and a shielding gas to protect the weld pool from air contamination. The supply of inert shielding gas offers a number of benefits over other conventional methods of fusing the metals using simple arc welding procedures. A few benefits of this welding method include improved tensile strength, finer grain hardness, excellent weld quality and appearance, microstructure improvement, and metallurgical properties over the source metal. In order to shed light on those sectors that have not yet realised their full potential, the primary objective of this research is to assess current advances in the TIG welding business. Thus, based on tests, parameters, and the kinds of materials used for welding, numerous TIG welding tales are compiled and investigated in this study article. The bulk of the mentioned studies state that the main parameter among them was found to be current, however gas flow rate and angle of weld utilising modern techniques have not been used up to that point. Based on the study, some recommendations for the manufacturing sectors are included below, which might be useful for future industrial applications.
Keywords: TIG welding, alloy; welding; hardness; strength, microstructure, literature review

I. INTRODUCTION

Tungsten Inert Gas (TIG) welding, also known as Gas Tungsten Arc Welding (GTAW), is a precise and versatile welding process. It involves creating an electric arc between a non-consumable tungsten electrode and the workpiece while shielding the weld zone with an inert gas, typically argon. The tungsten electrode remains unaffected during the process, making it non-consumable. TIG welding is a part of welding process and it can be widely used in modern industries for joining either similar or dissimilar materials. TIG welding has advantages like joining of similar and dissimilar metals at very high quality weld, low heat affected zone, absence of slag etc. Gas tungsten arc welding wildly uses a non-consumable tungsten electrode to produce the weld because it creates a very high temperature to weld the metals [01]. Among various available manufacturing methods, the TIG welding process overcomes the problems like high associated costs and generation of large amount of scrap by joining smaller work-pieces together and subsequently machining the component to the desired dimensions, thus reducing the required material to a large extent. Moreover, welded component have comparable quality and structural integrity and ensures reliability and long-term functioning of the component without failure [02]. Currently, TIG welding is an effective welding process to manufacture good quality structural components with great industrial potential [03]. It is an arc welding process in which coalescence of material is accomplished by the application of heat generated by an electric arc struck between the non-consumable tungsten electrode and workpiece. During welding, the faying surface of the material is melted and solidified and the weld pool is protected from atmospheric contamination by an inert gas purging out from the TIG torch [04]. It is well known that the quality of weld joint extensively depends on the weld bead geometry [5]

II. LITERATURE REVIEW

Li et al., (2007) [06] suggested that the most typical and industrially used type of welding, hybrid welding, has a variety of changes to achieve high speed TIG welding in many elements of shielding gas, welding current or arc voltage waveform, and hybrid welding. They proposed a double electrode GTAW (DE-GTAW), which omits a portion of the melting current in a typical GTAW process by using an inert tungsten electrode. While the base metal current in DE-GTAW could still be adjusted at the correct level, it was advised that the welding current be raised to speed up the welding process. With the non-consumable tungsten electrode of the DE-GTAW process being replaced with a consumable welding wire electrode recently, a new method known as consumable DE-GTAW was created. Nomura et al., (2017) [07] did a thorough analysis of the DE-GTAW process and found that by adding a tungsten electrode as a bypass to a single GTAW power source, the process can increase the melting current of filler metal while the base metal current can still be controlled at a desired level. In order to create a steady bypass arc, the horizontal space between the tungsten end and welding wire end needs to be less than 5 mm. The tungsten electrode's burn-off is likely to occur more quickly due to the short distance. Dancette et al., (2023) [08] demonstrated that the softening in the heat-affected zone is significantly influenced by the kind of dual-phase steel.

They noticed a significant HAZ softening, especially in the sub-critical area when DP980 steel was used instead of DP450 steel. The tempering of martensite, which causes the BCT structure to lose its tetragonality and the dislocation density to decrease, is the cause of HAZ softening in higher strength dual-phase steels. However, no HAZ softening is often seen in the case of RSW of DP600 steel in both identical and different configurations. The impact of RSW parameters on the microstructure and load-bearing capability of DP 600 steel has been the subject of several investigations.). Kumar et al., (2016) [09] examined the mechanical characteristics and microstructure of SS 304. Low, medium, and high heat combination TIG welding was employed for this purpose. In comparison to joints manufactured using medium or high heat, joints created using low heat showed higher ultimate stress. The primary conclusion of this study was that copper may be used in addition to SS 304 when TIG welding copper and SS 304 together. Muthupandi et al., (2015) [10] hypothesised that precipitating brittle intermetallic phases like (sigma) or (chi) would occur when using larger heat inputs. However, when large amounts of heat are applied, the delayed cooling that follows encourages the phase change and results in a more advantageous ferrite-austenite phase balance. Low heat inputs, on the other hand, result in high ferrite concentrations and vigorous chromium nitride precipitation. Additionally, the toughness and corrosion resistance are compromised by the use of low heat input and quick cooling rates. Shi et al. (2014) [11] suggested a closed loop control system design to address the instability issue with the open-looped control system for the consumable DE-GMAW. Using a fuzzy controller, a stable welding process with improved efficiency and less spatter was produced. According to Eboo, the laser beam was found to stabilise the welding current and arc voltage, lower arc column resistance, and boost the depth-to-width ratio of the finished weld look. Consequently, laser-MIG/MAG hybrid welding is a crucial method for achieving high speed welding. Metzbower et al., (2012) [12] studied how the hardness changed in mild steel gas tungsten arc welding pass by pass. The traditional techniques for observing a material's microstructure, such light optical microscopy and scanning electron microscopy, only reveal the microstructures at a few chosen places on the surface, making them inappropriate for examining the inhomogeneity of microstructures. However, using the surface hardness mapping approach makes it simple to examine the microstructure of the whole weld zone and investigate how mechanical characteristics and microstructure are distributed. The goal of this work is to evaluate how hardness maps may be used to investigate the microstructure and mechanical characteristics of welded samples, as well as to measure the changes in hardness that weld heat causes. Kim and Winkler et al. (2013) [13] have done substantial research in the fields of heat and fluid movement. A typical type of junction seen in the pipe systems of nuclear power plants is the circumferential weld. Due to the massive walls of these pipe systems, the butt weld frequently consists of many weld passes, and circumferentially arc welded walls are crucial in pressure vessel, nuclear, and aerospace engineering applications. These systems' failure is a result of their inability to endure severe temperatures. The weld surrounding it and within it is becoming worse. Residual strains, a by-product of the arc welding process, are of particular significance to the welding industry. Tungsten inert gas welding (TIG) is a common joining method for high-strength welding of these structures. Due to nonlinear temperature gradients during welding, it is challenging to prevent residual stress fields. In actuality, the material experiences intense localised heating (expansion) in and around the weld zone, followed by fast cooling (contraction). High magnitude residual stresses on the order of the material's yield strength might seriously jeopardise the structural integrity of operationally welded structures inside the heat affected zone (Miao et al., and Zhang et al., (2018) [14] proposed the inclusion of a further non-consumable electrode to the consumable process. The explanation proposes that two non-consumable electrodes might be added to the traditional consumable electrode configuration. They developed a method version in which, in order to improve the depth of weld penetration, arcs from both sides of the weldment were injected. The same power source was used to power a current bypass that powered both electrodes. In the metal joining of thicker plates, a large amount of weight is given to the rate of metal deposition. Kanemaru et al., (2019) [15] recommended the modified TIG-MIG hybrid welding technique to achieve a greater rate of weld metal depositions with a steady MIG arc by taking the bead on plate weld arrangement into account. Furthermore, they claim that a TIG welding procedure may shorten welding time by up to 44% while still producing excellent butt and fillet joints free of flaws. Comparing the weld joint's hardness to that of the MIG-welded test sample, an improvement in joint toughness was seen. The utilisation of several heat sources during welding results in better control of the heat-affected zone and increased weld metal deposition in tight spaces. Vasudevan et al., [16] A-TIG welding was developed as a solution to the problem of inadequate depth penetration of TIG welding joints, and its effects on the weldability of 304LN and 316LN austenitic stainless steel have been assessed in terms of weld bead geometry, microstructure, and mechanical properties. According to the study, employing the A-TIG welding procedure, the complete depth of penetration in 10 mm thick 304LN and 12 mm thick 316LN could be reached in one pass. Miki et al., (2021) [17] examined how TIG dressing repaired transversal and longitudinal attachments with pre-fatigued fillet-welded joints. Steel SM50 was used for the attachment plates whereas steel SM50 was used for the main plates. Four points bending was used for fatigue tests. Pre-fatigue testing was done on 40 as-welded specimens in total (20 longitudinal and 20 transversal).

To create fatigue fractures, the transversal attachments were subjected to loads ranging from 280 MPa to 450 000 cycles. In the meanwhile, the longitudinal attachments were loaded with the same 280 MPa stress range but with 300,000–350,000 cycles. Non-destructive testing were conducted to determine the size and forms of any potentially caused fractures after this loading step for both test series. Two instances were discovered. In the first instance, no fractures were seen in several pre-fatigued specimens. The second instance involves the discovery of fractures at the weld toe for additional specimens that ranged in depth from 2 to 6 mm. TIG dressing was used to restore the pre-fatigued welded joints. After TIG treatment, the weld toe radius was measured to be 5 mm on average. TIG might fuse at a depth of 3 to 4 mm. It was discovered that while TIG can successfully re-melt the initial cracks in certain specimens, there are still underlying fissures in other specimens. Chen et al., (2022) [18] investigated on the low deposition rate problem associated with the TIG welding. However, as this process required an oxidizing atmosphere for shielding the weld pool, it was not suitable for joining high strength steel. Improve deposition rate was also achieved by employing the DE-GTAW. However, the process required a special circuit arrangement. The aforementioned combined arc processes still had deficiencies associated with the conventional TIG and MIG processes, especially in weld pool behaviour and bead formation.

III. CONCLUSIONS AND RESEARCH IMPLICATIONS

In conclusion, the research implications of Tungsten Inert Gas (TIG) welding are significant and far-reaching. Through ongoing research and development, TIG welding has the potential to revolutionize various fields and industries. In terms of process optimization, research efforts aim to fine-tune welding parameters, such as current, weld speed, and shielding gas composition. By optimizing these variables, researchers can enhance the quality, efficiency, and productivity of TIG welding processes, resulting in improved weld joint integrity and reduced defects. Furthermore, TIG welding research delves into material science and metallurgy, investigating the microstructure, phase transformations, and mechanical properties of welds. This knowledge helps researchers develop techniques to control the heat-affected zone, minimize distortion, and improve weld strength and toughness. Additionally, the ability of TIG welding to join dissimilar materials opens up possibilities for novel material combinations and applications, prompting further research in this area. Automation and robotics play a crucial role in TIG welding research, aiming to develop advanced robotic systems and intelligent algorithms. These advancements enhance precision, repeatability, and productivity by integrating sensors, machine vision, and artificial intelligence to monitor and control the welding process. This research leads to improved weld quality, reduced errors, and increased operational efficiency. Another area of research is the application of TIG welding in additive manufacturing, enabling the creation of complex geometries and functional prototypes. Investigations into process parameters, deposition strategies, and post-processing techniques for TIG-based additive manufacturing contribute to the development of high-accuracy, mechanically robust components. Lastly, TIG welding research focuses on environmental impact and sustainability. By exploring alternative shielding gases, consumables, and power sources, researchers aim to reduce energy consumption, emissions, and waste generation associated with TIG welding operations. This research aligns with the broader goal of promoting sustainability in the manufacturing industry. Overall, TIG welding research has implications across multiple fields, including process optimization, material science, dissimilar material joining, automation, additive manufacturing, and sustainability. Continued research in these areas will not only advance the capabilities of TIG welding but also drive innovation and progress in manufacturing, engineering, and materials science

IV. LIMITATIONS

The literature review was limited to the last decade to explore the significant effects of the TIG welding in application.

V. ACKNOWLEDGMENT

The authors are thankful to the RIMT University, Mandi Gobindgarh (Punjab) for providing the platform for this research work.

REFERENCES

[1] Parthiv T. Trivedi, Ashwin P. Bhabhor, A review on techniques for optimizing process parameters for TIG Welding Aluminium,International Journal for Scientific Research & Development| Vol. 1, Issue 9, 2013, ISSN (online): 2321-0613.

[2] A.B. Naik, A.C. Reddy, Therm. Sci. Eng. Progress 8 (2018) 327–339.

[3] Y. Xu, G. Fang, N. Lv, S. Chen, J.J. Zou, Rob. Comput. Integr. Manuf. 32 (2015)25–36.

[4] Durgutlu, A. (2004). Experimental investigation of the effect of hydrogen in argon as a shielding gas on TIG welding of austenitic stainless steel. Materials & Design, 25(1), 19–23. doi:10.1016/j.matdes.2003.07.004

[5] Juang, S. ., & Tarng, Y. . (2002). Process parameter selection for optimizing the weld pool geometry in the tungsten inert gas welding of stainless steel. Journal of Materials Processing Technology, 122(1), 33–37. doi:10.1016/s0924-0136(02)00021-3

[6] Meng, X., Qin, G., Zhang, Y., Fu, B., & Zou, Z. (2014). High speed TIG–MAG hybrid arc welding of mild steel plate. Journal of Materials Processing Technology, 214(11), 2417–2424
[7] Chen, J., Zong, R., Wu, C., Padhy, G. K., & Hu, Q. (2017). Influence of low current auxiliary TIG arc on high speed TIG-MIG hybrid welding. Journal of Materials Processing Technology, 243, 131–142.
[8] Sahasrabudhe, O. S., & Raut, D. N. (2018). Analytic framework on parameter ranking for hybrid TIG MAG arc welding of mild steel. Journal of Advanced Research, 12, 27–37.
[9] Somani, C. A., & Lalwani, D. I. (2019). Experimental Investigation of TIG-MIG Hybrid Welding Process on Austenitic Stainless Steel. Materials Today: Proceedings, 18, 4826–4834
[10] Vidyarthy, R. S., & Sivateja, P. (2020). Influence of activating flux tungsten inert gas welding on mechanical and metallurgical properties of the mild steel
[11] Manai, A. (2021). An analysis of pre-fatigued TIG-treated welded structures. Engineering Failure Analysis, 121, 105150.
[12] Dancette et al., 2023, Investigation of a novel TIG-spot welding vis-à-vis resistance spot welding of dual-phase 590 (DP 590) steel: Processing-microstructure-mechanical properties correlation Bijoy Rajak https://doi.org/10.1016/j.matchemphys.2022.127254
[13] Kumar et al., Mechanical properties assessment of TIG welded SS 304 joints Aishna Mahajan, Harvinder Singh, Satish Kumar, Santosh Kumar https://doi.org/10.1016/j.matpr.2021.12.133
[14] Devendranath Ramkumar, K., Bajpai, A., Raghuvanshi, S., Singh, A., Chandrasekhar, A., Arivarasu, M., & Arivazhagan, N. (2015). Investigations on structure–property relationships of activated flux TIG weldments of super-duplex/austenitic stainless steels. Materials Science and Engineering: A, 638, 60–68.
[15] Meng, X., Qin, G., Zhang, Y., Fu, B., & Zou, Z. (2014). High speed TIG–MAG hybrid arc welding of mild steel plate. Journal of Materials Processing Technology, 214(11), 2417–2424.
[16] Ghazanfari, H., Naderi, M., Iranmanesh, M., Seydi, M., & Poshteban, A. (2012). A comparative study of the microstructure and mechanical properties of HTLA steel welds obtained by the tungsten arc welding and resistance spot welding. Materials Science and Engineering: A, 534, 90–100. doi:10.1016/j.msea.2011.11.046
[17] Arora, H., Mahaboob Basha, K., Naga Abhishek, D., & Devesh, B. (2021). Welding simulation of circumferential weld joint using TIG welding process. Materials Today: Proceedings. doi:10.1016/j.matpr.2021.06.315
[18] Comparative study between TIG-MIG Hybrid, TIG and MIG welding of 1008 steel joints for enhanced structural integrity https://doi.org/10.1016/j.sciaf.2022.e01329