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AN EXPERIMENTAL INVESTIGATION ON THE INFLUENCE OF ROOT GAP AND GROOVE ANGLES ON 304 STAINLESS STEEL WELDING USING TUNGSTEN INERT GAS (TIG) WELDING: A REVIEW

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Abstract : In order to increase the ultimate tensile strength, this review paper presents an experimental examination on the effects of root gap and groove angles during tungsten inert gas (TIG) welding of 304 stainless steel. The Taguchi approach is used in the study to enhance the mechanical qualities and optimize the welding conditions. In this study, the results of several research investigations on TIG welding for stainless steel welding are discussed. In order to shed light on the effects of root gap and groove angles on TIG welding of 304 stainless steel, this review combines the results from several experiments. A strategy that shows promise for improving the ultimate tensile strength of the weld joints is the optimization of welding parameters using the Taguchi method. The research that has been presented advances knowledge of TIG welding procedures for stainless steel applications, making it easier to create welds that are both high-quality and long-lasting.

Keywords – TIG welding, tensile strength, Taguchi method.

1 INTRODUCTION

A process of uniting two metals, with or without filler material, that are similar or dissimilar is welding. TIG welding, also referred to as standard Arc welding, is one of the widely used methods. This technique is employed because it has strong controlling qualities to locally deliver heat to the welding line [1]. By inducing coalescence, welding, one of the fabrication processes, is used to unite metals, taking the role of other joining techniques like bolting and riveting. TIG welding creates strong joints and is preferred by the majority of manufacturers for mechanical assembly. Even in TIG welding, filler material is typically employed in metal joining procedures. The most crucial factor is if the welded samples are approved. Non-destructive testing of these materials is done at different stages to gauge the quality of the welds in order to match their specifications and norms. Even though the appropriate precautions were taken throughout the welding process, the weld joint inspection found that it does not fulfil its standards owing to lack of penetration, under cuts, cracks, etc. Radiography, ultrasonic testing, and acoustic testing are a few of the non-destructive examination procedures. To identify the weldment faults, these tests can be carried out more easily. The majority of the time, these tests are performed on casting-produced goods. The majority of components today, including crucial forms and structures, are made via welding.

The Taguchi technique is an effective technique that employs a unique design to analyze the parameter space with few experiments using orthogonal arrays. In a factorial design, both the number of levels and the number of factors rise exponentially. This method offers an effective, straightforward, and systematic approach to design optimization for cost, performance, and quality. It becomes necessary to conduct a large number of experiments as the factors and levels rise. An orthogonal array is created in the Taguchi method to investigate all parameters in order to solve the issue. The S/N (signal to noise) ratio is used to transform these data. Three categories nominal-the better, lower-the better, and larger-the better can be used to describe this S/N ratio [2]. An electric arc is created and maintained between a non-consumable tungsten electrode (DCEN) and the component to be welded during the process of gas tungsten arc welding (GTAW). The heat-affected zone, molten metal, and tungsten electrode are protected from ambient contamination by the inert gas that exits the GTAW torch. Since they don't react with the metals being connected, Argon and Helium are often the preferred inert gases for TIG welding. The shielding gas acts as a blanket over the weld, keeping out the air's active components [3]. The best welding technique for stainless steel is TIG. "Tungsten Inert Gas Welding" is what this acronym stands for. Early in the development of these steels for cutlery applications, the name "stainless" was developed. It was used as a generic name for these steels and is currently used to refer to a variety of steel kinds and grades for applications requiring resistance to corrosion or oxidation. Stainless steels are used because of their great toughness and general corrosion resistance. The most common stainless steels are austenitic (300 series), which are ductile and easy to shape into the necessary geometries. For applications requiring great toughness and resistance to surface wear, they can also be casehardened to generate alternating layers of martensitic and austenitic structures. However, because of their higher initial cost and susceptibility to pitting and inter granular (IGC) corrosion, their use is restricted in comparison to that of other ferrous alloys. A cell was created to investigate these localized corrosion events in structural locations of interest by conducting polarization (spot) tests on metallic surfaces in precisely specified areas [4].

The introduction provides a brief overview of the significance of SS 304 and TIG welding and the purpose of the study. The thesis statement is clearly stated, which is to investigate the mechanical properties (tensile strength and Hardness) of SS 304 weld joints produced by TIG welding.

1.1 TIG welding process

A non-consumable tungsten terminal is used to provide the weld in gas tungsten circular segment welding, also known as tungsten latent gas (TIG) welding. An external source supplies the filler metal, usually in the form of an exposed metal filler bar. A shielding latent gas, such as argon, protects the weld pool area from the environment and any contaminants. Despite the fact that some welds, known as autogenous welds, don't require it, filler metal is frequently used. Welding small pieces of tempered steel and light metals like aluminum, magnesium, and copper compounds is best done using TAW. The interaction gives the welding supervisor greater control over the welding cycle than other methods, resulting in more solid, high-upright welds. The drawbacks of GTAW include that it is slower and more complicated than many other welding techniques.

TIG welding follows the same rules as bent welding. The severe focus curve between the tungsten anode and work piece is delivered during TIG welding. The curve generates a significant amount of heat energy, which is used to attach the metal plate. The weld surface is protected from oxidation by the safeguarding gas, which is used. The TIG welding process makes use of the heat produced by an electric bend between the metals that need to be welded and a tungsten-based terminal that is positioned inside the welding lamp. To protect the tungsten terminal and weld pool, a dormant or declining gas shield is placed over the curve area. The welder physically inserts a bar of filler metal into the weld pool [5].

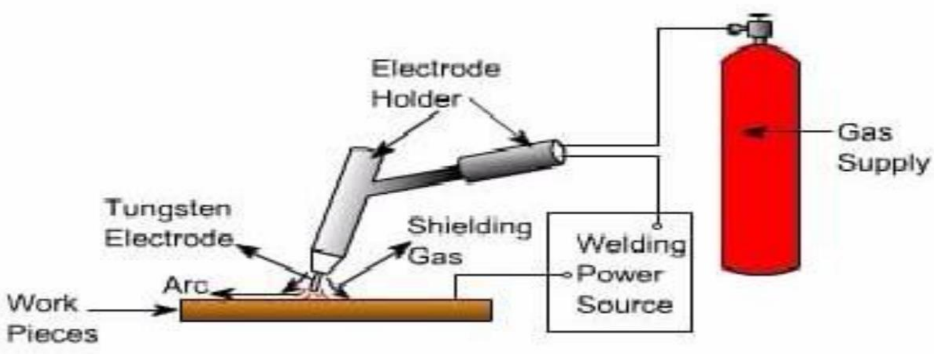

Fig. :1. TIG welding [6]

2 LITERATURE SURVEY

Table 1: Literature survey

Sr. No.	Title of Research Paper	Author Name	Year	Remark
1	Experimental and numerical analysis on tig arc welding of stainless steel using RSM approach	Sattarpanah Karganroudi, S. Moradi, Aghaee Attar, Rasouli, Ghoreishi, Lawrence, Ibrahim,	2021	increasing the current and decreasing scanning speed, causes the weld bead width to widen and the depth of penetration extended.
2	Optimization of 316 stainless steel weld joint characteristics using Taguchi technique	P. Bharatha, V.G. Sridharb, M. Senthil kumarb	2014	It has been noted that the root gap, current, and speed all have some bearing on the material's tensile and bending strengths.
3	Experimental investigation for welding aspects of stainless steel 310 for the process of TIG welding.	V.Anand Raoa, Dr.R.Deivanathan	2014	Better tensile and bending strength was obtained with the filler material 309L.

4	Effect of tig welding parameter of welded joint of stainless steel ss304 by TIG welding	Manabendra Saha, S. S. Dhami	2019	When stainless steel SS304 was welded utilising optimised settings, joint tensile strength and hardness increased by 10.56% and 7.36%, respectively. Ultrasonic testing was also used to assess the weld joints for interior defects.
5	A review on experimental investigation of autogenous tungsten inert gas (TIG) welding on mild steel	Sourabh Raikwar, Arun Patel	2021	The anticipated outcomes of the standard TIG welding procedure demonstrate that the maximum depth of penetration was intended to be attained with the parametric combination of the minimum welding speed and the maximum current.
6	Experimental studies on high thickness welding of ss316L using TIG-MIG welding	Mohammad Kamran Habeeb	2022	The high thickness SS materials in the range of 20-60 mm based on the required protocols are mainly used for the fabrication of sub components in vacuum vessel. Therefore, the Combination of TIG-MAG is proposed
7	Studies on mechanical properties, microstructure and fracture morphology details of laser beam welded thick ss304l plates for fusion reactor applications	Ramesh Kumar Buddua, N. Chauhana, P.M. Raolea, Harshad Natu	2015	Weld microstructures with narrow HAZ show combined characteristics of dendritic and cellular structures, and delta ferrite is present in the welds, which is further supported by increased Ferrite Number data.
8	Multi-objective optimization of process parameters in TIG-MIG welded AISI 1008 steel for improved structural integrity	Cynthia Samuel Abimaa, Stephen Akinwale Akinlabib, Nkosinathi Madushelea, Olawale Samuel Fatobac, Esther Titilayo Akinlabid	2021	This study demonstrates the value of the grey relational grading system in accomplishing a multi-objective TIG-MIG welding process optimisation.
9	Optimization of process parameters in tig welding of AISI 4140 stainless steel using Taguchi technique	L. Natrayan, R. Anand, S. Santhosh Kumar	2020	The welding current at level 1 (A1), weld speed at level 3 (B3), and filler diameter at level 3 (C3) are the best process parameters for tensile strength. According to ANOVA results, welding speed is the biggest factor in reaching tensile strength.
10	Investigation on the process parameters of TIG-welded aluminium alloy through mechanical and microstructural characterization	Jing-long Li, Muhammad Taimoor, Mohammad Nouman Siddiqui, Sumair Uddin Siddiqui, Jiang-tao Xiong	2020	The optimum heat input value to weld a thick plate of Al-5083 alloy was found to be 1e2 kJ/mm with 270e320 A welding current and 2e4 mm/s torch traveling speed. Above and below these parameters, joint properties were declined

11	Mechanical properties and microstructural investigations of tig welded 40 mm and 60 mm thick ss 316l samples for fusion reactor vacuum vessel applications	Ramesh Kumar Buddu, N. Chauhan, P.M. Raole	2014	High-thickness SS316L plates were successfully TIG welded using a multi-pass process, with no weld flaws found. The welded samples were then further characterised for their mechanical properties and microstructure.
12	Mechanical properties assessment of TIG welded SS 304 joints	Aishna Mahajan, Harvinder Singh, Satish Kumar, Santosh Kumar	2022	The current study's objective is to determine how the filler material composition affects the welding characteristics of stainless steel (SS) 304 when it is welded using a semi-automatic TIG welding procedure.
13	Mechanical Assessment of SS 304 & SS316L by using Pulsed TIG Welding Process	Darbha Rohit, Kunapuli Naga Sriranga Abhiram, Boppidi Sumanth Reddy , Valaboju Anvesh	2021	Tensile testing was done both before and after the post-welding heat treatment process, and microstructure analysis was done.
14	Characterization and analysis of TIG welded stainless steel 304 alloy plates using radiography and destructive testing techniques	Ajay Prakash Pasupulla, Habtamu Abebe Agisho, Suresh Seetharaman, S. Vijayakumar	2021	examining the mechanical behaviours of a welded joint and flaws caused by these mechanical behaviours, such as tensile testing, bending, hardness testing, and impact testing performed on a work specimen in destructive testing.
15	Influences of Groove Angles and Filler Metals on 304L Stainless Steel to AISI 1040 Carbon Steel Dissimilar Joint by Gas Tungsten Arc Welding	Eriek Wahyu Restu Widodo, Vuri Ayu Setyowati, Suheni, and Ahmad Rilo Hardianto	2019	With ER 308L-16 filler metal, the groove angle of 60° produced the highest tensile strength (614.54 MPa). The lowest tensile strength, 578.66 MPa, was attained with a 45° groove angle and ER 70S-6 filler metal.

3 CONCLUSION

It is clear from the studies that have been reviewed that the Taguchi method is a useful strategy for improving welding parameters and weld qualities. Critical criteria that determine the final tensile strength and mechanical characteristics of the weld joints include the root gap, groove angles, welding current, welding speed, and filler material choice. Overall, this analysis emphasizes the need of taking root gap, groove angles, and welding parameters into account when employing TIG welding to provide the best possible weld quality in 304 stainless steel. The results highlight the Taguchi method's potential for process optimization as well as the significance of material choice and microstructural control. Researchers and practitioners can improve the welding process by putting the lessons learned from this paper into practice, leading to stronger and more dependable weld joints for 304 stainless steel applications.

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