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"A COMPREHENSIVE REVIEW ON RECENT STUDIES OF TIG WELDING ACROSS DIFFERENT MATERIALS"

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ABSTRACT

Welding, the process of joining metals through the application of heat or pressure, is a crucial fabrication method widely employed for material bonding. Specifically, Tungsten Inert Gas Welding (TIG), also known as Gas Tungsten Arc Welding (GTAW), is a prominent technique in this domain. This review aims to comprehensively explore the various elements and equipment involved in TIG welding. Additionally, it investigates the impact of key welding parameters such as welding current, gas flow rate, electrode angle, and electrode type, highlighting their direct influence on output parameters including hardness, tensile strength, weld strength, weld quality, and microstructure.

Key Words: *TIG Welding, Electrode, Hardness, Tensile Strength, Welding Parameters.*

I. INTRODUCTION

TIG welding, originating during the Second World War around 1940, is a welding technique utilizing a tungsten electrode to heat the metal being joined. To safeguard the weld from impurities during the process, inert gases like argon or helium are employed as shielding. One notable feature of TIG welding is its versatility, as it can be applied to various metals and thicknesses. The method is highly esteemed for its quality and broad applicability, extending to metals such as steel, bronze, nickel, brass, copper, magnesium, aluminium, and gold. TIG welding stands out for its precision and cleanliness, allowing for a superior aesthetic finish. The welder can finely control the amount of heat applied through a foot pedal, ensuring meticulous weld control. Moreover, TIG welding is distinguished by its lack of sparks, smoke, and fumes, contributing to a clean working environment.

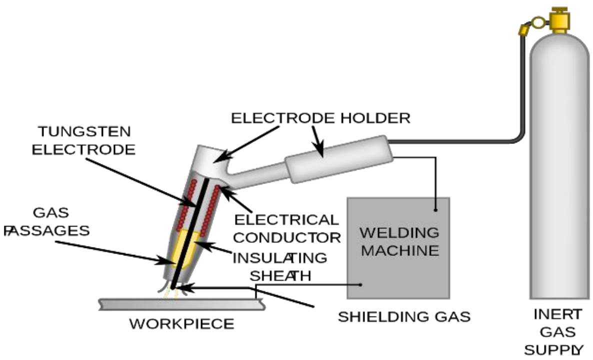

Fig-1: Diagram of TIG Welding Equipment [8]

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Working Of TIG Welding:

In TIG welding, a sustained arc is established between a durable, non-consumable tungsten electrode and the work-piece. This occurs within an inert atmosphere, typically composed of argon, helium, or a mixture of both, to shield the weld from atmospheric contamination and oxidation. The decision to use filler material during welding depends on factors such as weld preparation and the thickness of the work-piece. Fillers can be introduced manually or automatically, depending on the specific welding process employed. The TIG welding process itself can range from manual operations to partially mechanized, fully mechanized, or completely automatic processes. Additionally, the welding power source can deliver either direct or alternating current based on the requirements of the welding application.

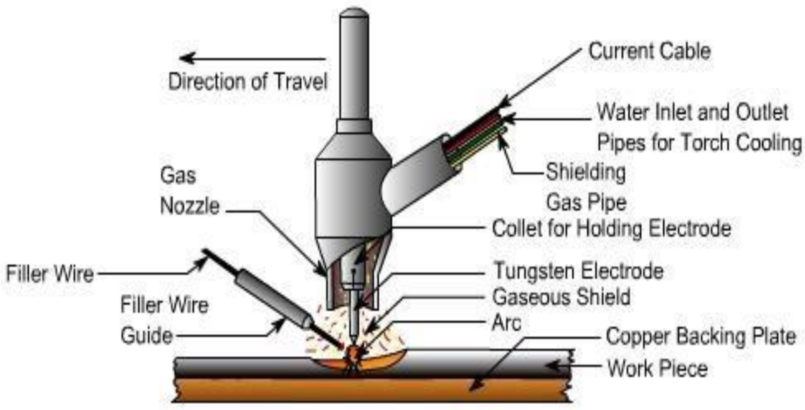

Fig-2**:** Working Principle of TIG Welding [9]

II. LITERATURE REVIEW

R.M.J. Konings' [1]"Physical and Mechanical Properties of Copper and Copper Alloys," serves as a pivotal resource for research on welding copper and its alloys the work extensively explores the fundamental characteristics of copper, including density, thermal conductivity, and mechanical strength these properties in the subsequent investigation into the welding of copper and its alloys. Delving into welding processes, parameters, and their effects on microstructure and mechanical properties, Konings' research offers valuable insights for optimizing welding methodologies in applications ranging from nuclear materials to various industrial contexts. The comprehensive nature of this literature review equips researchers with essential knowledge to advance the understanding and application of copper and copper alloys in welding processes.

A. Kumar and Sundarrajan [2] conducted a study on optimizing the mechanical properties of pulsed TIG welds by investigating process parameters. They utilized the Taguchi method and developed regression models to enhance weld quality characteristics such as Ultimate Tensile Strength, Yield Strength, and hardness. The Taguchi method, chosen for its practicality, allows for improved output quality without increasing experimental costs and reduces the number of experiments needed. The researchers correlated microstructures of the welds with their mechanical properties. Additionally, the obtained welds underwent a cold planishing process to relieve internal stresses and reform grains, further enhancing their mechanical properties.

Tseng's study in 2011 [3] delved into the impact of the activated TIG (Tungsten Inert Gas) process on various aspects of welding 316L stainless steel. By employing different flux materials such as TiO_2, MnO_2, MoO_3, SiO_2, and Al_2O_3, the investigation focused on weld morphology, angular distortion, delta ferrite content, and hardness. The author conducted experiments using a 6 mm thick plate, employing specific welding parameters, including a welding current of 200 Amps, welding speed of 150 mm/min, and a gas flow rate of 10 l/min. Results revealed that the use of SiO_2 flux notably enhanced joint penetration. However, Al_2O_3 flux adversely affected weld depth and bead width when compared to the conventional TIG process. This research provides valuable insights into the nuanced effects of different flux materials on the welding characteristics of 316L stainless steel.

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Harmish Bhatt [4], the focus was on understanding the influence of process parameters, specifically the gas flow rate and welding current, in the Tungsten Inert Gas (TIG) welding of aluminum alloy 7075. The study comprised two sets of experiments. In the first set, the investigation centered on examining the mechanical properties, specifically the Ultimate Tensile Strength and hardness, under different parameter conditions. Subsequently, in the second set of experiments, the aim was to optimize the welding process parameters. This optimization involved restricting the values of the gas flow rate and welding current to determine the combination that would yield the maximum Ultimate Tensile Strength. The research contributes valuable insights into the nuanced relationship between process parameters and mechanical properties in TIG welding of aluminum alloy 7075, with a practical emphasis on optimization for enhanced performance.

B Ravindar and K Gururaj [5] conducted a study employing the pulsed current Tungsten Inert Gas (TIG) welding method, focusing on aluminum alloy 5053 sheets with a thickness of 4mm. The ultimate goal was to achieve a final workpiece dimension of 100x100x4 mm. ER 5356 was utilized as the filler metal, varying its diameter, and weld samples were produced under different conditions by manipulating welding parameters, including welding current, gas flow rate, and filler rod dimensions. Impact tests were carried out, and Vickers Hardness values were obtained. Notably, at specific process parameters (welding current of 180 A, gas flow rate 10l/min, and filler rod diameter 1.6 mm), the Vickers hardness was observed to be low due to inadequate fusion. However, optimizing these parameters, such as increasing welding current to 240A, gas flow rate to 12l/min, and using a filler rod with a diameter of 3.2 mm, significantly improved the Vickers Hardness values. The hardness of the weld zone exhibited variations with distance from the weld center, attributed to changes in microstructure. The study attributes the enhancement in Vickers Hardness and microhardness properties to the grain size refinement in the fusion zone achieved through pulsed current welding.

K. Srinivas and colleagues [6] conducted Tungsten Inert Gas (TIG) welding on AA 6063, using plates with dimensions of (150x60x6) mm^3. The study involved varying the weld current while keeping other parameters constant, and evaluations were made on hardness, impact resistance, and tensile strength. The process parameters under consideration were weld current and the use of Argon as a shielding gas. Two plates of identical dimensions were joined in a square butt joint configuration, resulting in dimensions of (150x100x6) mm^3. The welding was performed in the forward direction, employing pulsed alternating current (A.C.). It was observed that an increase in welding current led to a rise in the welding heat input in AA 6063, consequently raising the likelihood of defects such as burns in the welded metal. These defects were found to have adverse effects on the mechanical properties and the overall quality of the welded metal. The study underscores the importance of carefully controlling welding parameters to mitigate defects and ensure the desired mechanical properties in TIG-welded AA 6063.

Yashwant Thakur and his colleagues [7] conducted an investigation into the Tungsten Inert Gas (TIG) welding parameters for AA 7005, chosen for its favorable welding characteristics and corrosion resistance. Their focus was on understanding how the strength and profile of the welded joint are impacted by the choice of material and welding technique. The experimental design was guided by the Taguchi method, allowing for a systematic exploration of various welding parameters. Microstructural analysis at different zones of the weldment was undertaken to draw comparisons between TIG welding and the base material. This analysis aimed to discern the effects of temperature distribution on the microstructure, providing valuable insights into the welding process and its influence on the material at a microscopic level.

Surendhiran. S et. al [8] conducted Tungsten Inert Gas (TIG) welding on sheets with dimensions of 250x150x2.4 mm, employing AA 5456. Their study focused on measuring microhardness at specific intervals across the weld, heat-affected zone (HAZ), and unaffected base metal. Notably, a fine and equated grain structure was achieved under optimized conditions, featuring a peak current of 80 A, base current of 4 A, welding speed of 230 mm/minute, and a pulse frequency of 2 Hz. In contrast, a coarse grain structure was observed under different welding parameters. The significance of this research lies in the identification of optimum conditions leading to improved mechanical properties. The regression models derived from the study also offer practical insights for the potential automation of the TIG welding process

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Ahmed Khalid Hussain and collaborators [9] conducted a study using aluminium alloy AA6361 to create test specimens with base metal dimensions of 4x50x200 mm. They utilized a Universal Testing Machine to assess the strength of the welded joint. AA6063 served as the filler metal, and the shielding gas consisted of 18% CO2 and 82% argon. The design of the weld joint, including the bevel angle and bevel height, played a significant role in influencing the tensile testing of the weld. Interestingly, at a welding speed of 0.3 cm/s, there was no remarkable change in the tensile strength of the weldment. However, an unexpected decrease in strength occurred at a welding speed of 1.2 cm/s due to insufficient weld bead penetration onto the root gap of the weldment. The study revealed a linear correlation between bevel height and welding speed, shedding light on the interplay of these parameters in the welding process.

Shailesh Kumar [10], a specimen measuring 100x20x3 mm was utilized for the welding of an Al 5083 series plate. The welding process involved specific parameters: a welding current ranging from 118 to 134A, a gas flow rate between 6-7 l/min, and a welding speed set at 90-105 mm/min. Following ASTM standards, the welded specimen underwent wire Electrical Discharge Machining (EDM) for cutting, and tensile strength was subsequently tested using a Universal Testing Machine (UTM). The highest tensile strength, reaching 127 MPa, was achieved at a welding current of 134A, a gas flow rate of 7 l/min, and a corresponding welding speed of 100 mm/min. Microstructural analysis of the weld pool revealed a refined grain structure, attributed to the rapid solidification caused by pulsing in the welding process. This resulted in well-fused welding joints and a tight structure, contributing to the observed peak tensile strength.

III. CONCLUSION

The amalgamation of the reviewed studies significantly contributes to the ongoing development of Tungsten Inert Gas (TIG) welding, offering a multifaceted perspective on various aspects of the process. By delving into these studies, researchers gain valuable insights that aid in optimizing crucial process parameters, improving mechanical properties, and unravelling the intricate microstructural details of welded joints across a spectrum of materials. These findings not only enrich the theoretical underpinnings of TIG welding but also hold tangible implications for industries that heavily depend on accurate and efficient welding processes.

One notable area of focus in the reviewed studies is the optimization of process parameters. Researchers and practitioners are keenly exploring the intricate relationships between welding conditions, such as current, gas flow rate, and filler material, and their impact on the mechanical properties of the welds. Understanding how adjustments in these parameters can enhance the ultimate tensile strength, hardness, and other mechanical characteristics is crucial for achieving superior weld quality. Studies, such as those by A. Kumar and Sundarrajan [2] and B Ravindar and K Gururaj [5], provide valuable methodologies and insights into achieving optimal weld quality through systematic parameter adjustments.

Furthermore, the studies delve into the microstructural nuances of welded joints, particularly when employing TIG welding on various materials. The exploration of different flux materials in the welding of 316L stainless steel, as conducted by Tseng [3], exemplifies how the choice of flux can significantly influence weld morphology, angular distortion, delta ferrite content, and hardness. Such investigations contribute to a deeper understanding of the subtle effects of welding processes on the microstructure of materials.

Practical implications arise from the advancements in TIG welding elucidated in these studies. Industries ranging from aerospace and automotive to repair and art can benefit from the refined methodologies and optimized parameters. For instance, the aerospace industry, constructing aircraft and spacecraft, stands to gain from the enhanced strength and precision offered by TIG welding, as highlighted by Yashwant Thakur and colleagues [7]. In the automotive sector, where secure construction and longevity are paramount, TIG welding's reduced corrosion over time makes it an invaluable choice, particularly in welding components like car fenders.

In conclusion, the collective findings from these studies not only deepen the theoretical understanding of TIG welding but also offer practical tools and insights for improving welding processes across diverse applications. As industries continue to seek advancements in efficiency, quality, and precision, the knowledge derived from these studies becomes instrumental in shaping the future of TIG welding technologies.

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