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"GTA Welding Process and Its Influence on Structure Properties Relationship for Petrochemical Industries"

Ritunjay Rai[1], Rishabh sharma[1], Rahul Rana[1], Abhinav madaan[1],
Dr. Rajeev Kumar[2*]
[1]*Under-graduate Students, Mechanical Engineering Department, GNIOT*
[2]*Assistant Professor, Mechanical Engineering Department, GNIOT*

ABSTRACT
One of the crucial production paths for most industrial businesses is welding as a fabrication technique. The compositional range of the material to be welded, the thickness of the base materials, and the type of current are only a few of the variables that influence which welding technique is best for a certain application. Because most metals quickly oxidize when they are molten, the weld area must be shielded from atmospheric contamination when using gas tungsten arc welding (GTAW) (argon, helium, nitrogen). One of the common methods for joining ferritic and austenitic stainless-steel fabrication is the GTAW technique. But today's biggest challenge is still the microstructural change that takes place during welding and at the weld junction. Development of a variety of water- and air- cooled torches, gas lenses to enhance shielding, and other process-enhancing accessories. Originally, the electrode rapidly overheated and tungsten particles were transported to the weld despite the metal's high melting point. The electrode's polarity was switched from positive to negative to solve this issue, however the alteration rendered it unusable for welding many non-ferrous materials. Ultimately, the invention of alternating current machines allowed for the stabilization of the arc and the production of excellent aluminum and magnesium welds. The GTAW technique has continued to evolve, and as a result, there are now numerous variations. The pulsed-current, manual programmed, hot-wire, dabber, and greater penetration GTAW techniques are among of the most well-liked ones.

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I. INTRODUCTION

Super-duplex stainless steel (SDSS) is widely used in various industries due to its good mechanical properties and high corrosion resistance. Its corrosion resistance is due to the increase in Cr, Mo, and N alloying contents. Welding is important for SDSS, but it can negatively affect the microstructure and corrosion resistance of welded joints. Different welding techniques have been successfully applied, but heat input during welding alters the mechanical and corrosion properties of welded joints. Low heat input leads to higher ferrite content and higher chromium nitride precipitation, while high heat input promotes the precipitation of brittle phases. The influence of heat input on the nanoindentation response and corrosion behaviors of SDSS is still poorly understood.

1.1. GTA WELDING PROCESS: - During the TIG welding process, the arc is formed between the tungsten electrode and the work. The arc that is produced by the electrode is intense and makes TIG welding perfect for high-quality welds. The electrode is not consumed during the weld. TIG welding requires great precision. The tungsten electrode heats up the objects enough so they can form a bond. TIG welding enables the joining of objects without the use of filler, though a filler metal is commonly used in TIG welding. TIG welding can be used for direct metal-to-metal welds and results in neater, spatter-free welds that are generally free of defects.

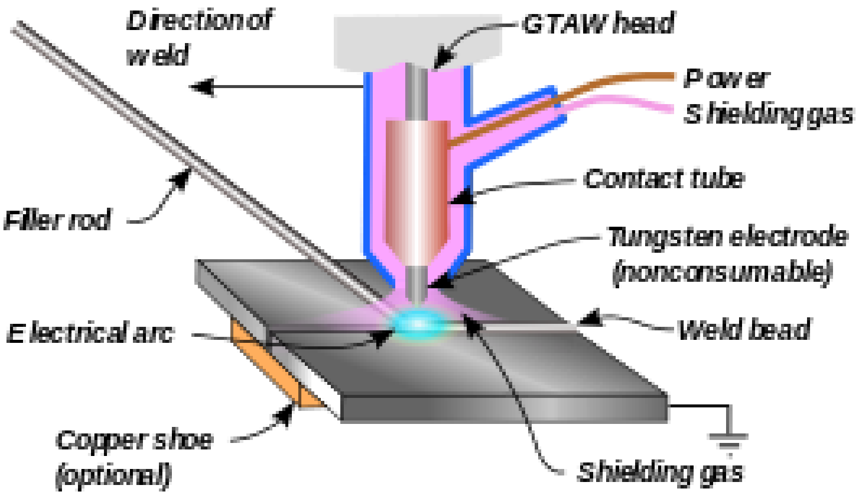

Fig. GTA WELDING PROCESS

(**Source**: https://www.researchgate.net/figure/Schematic-Diagram-of-TIG-welding-process_fig1_319609786)

1.2. GTAW PROCESS PARAMETERS

1.2.1. WELDING CURRENT: - Welding current is the most influential variable in arc welding process which controls the electrode burn off rate, the depth of fusion and geometry of the weldments. Current has direct influence on weld bead shape, on welding speed and quality of the weld. Most GTAW welds employ direct current on electrode negative (DCEN) (straight polarity) because it produces higher weld penetration depth and higher travel speed than on electrode positive (DCEP) (reverse polarity). Besides, reverse polarity produces rapid heating and degradation of the electrode tip, because anode is more heated than cathode in gas tungsten electric arc. Higher current in GTA welding can lead to splatter and work piece become damage. Again, lower current setting in GTA welding lead to sticking of the filler wire. Sometimes larger heat affected area can be found for lower welding current, as high temperatures need to apply for longer periods of time to deposit the same amount of filling materials. Fixed current mode will vary the voltage in order to maintain a constant arc current. [1], [2]

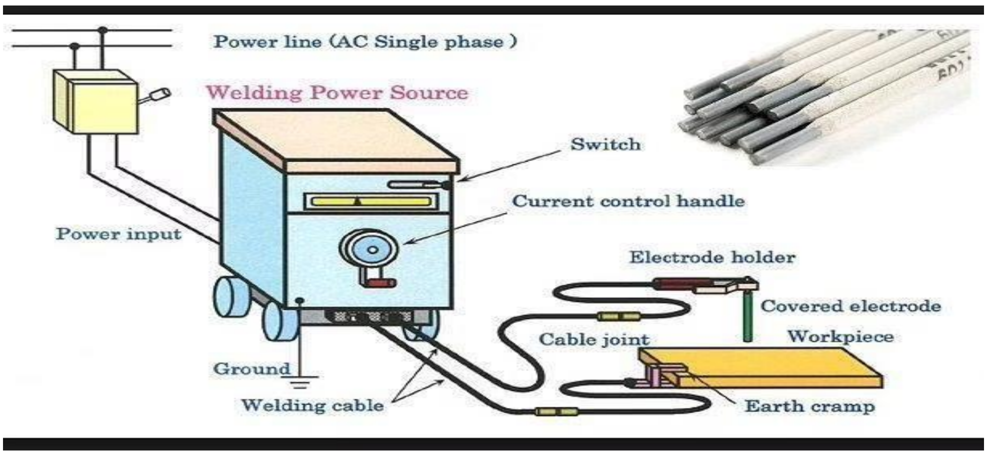

Fig: GTA welding power setup

(Source: https://www.slideshare.net/hakimm/welding-for-engineers-chapter-1)

1.2.2. WELDING VOLTAGE: - This is the electrical potential difference between the tip of the welding wire and the surface of the molten weld pool. Welding voltage can be fixed or adjustable depending on the GTA welding equipment. It determines the shape of the fusion zone and weld reinforcement. A high initial voltage allows for easy arc initiation and a greater range of working tip distance. However, it produces wider, flatter and less deeply penetrating welds than low welding voltages, depth of penetration is maximum at optimum arc voltage, to high voltage on the other hand will lead to large variable in welding quality. [3]

1.2.3. WELDING SPEED: - Speed of welding is defined as the rate of travel of the electrode along the seam or the rate of the travel of the work under the electrode along the seam. [4] Weld Travel Speed = Travel of electrode/arc time, mm/min. [5] Welding speed is an important parameter for GTAW welding. The effect of increasing the welding speed for the same current and voltage is to reduce the heat input. The welding speed does not influence the electromagnetic force and the arc pressure because they are dependent on the current. The weld speed increase produces a decrease in the weld cross section area, and consequently penetration depth (D) and weld width (W) also decrease, but the D/W ratio has a weak dependence on travel speed. These results suggest that the travel speed does not influence the mechanisms involved in the weld pool formation, it only influences the volume of melted material. Normal welding speeds are from 100 to 500 mm/min depending on current, material type andplate thickness. [6]

***1.2.4.* ELECTRODE EXTENTION (STICKOUT): -** Electrode extension or also called stick-out length or stick-out distance refers to the length of the welding wire that extends outside the contact tube. The welding electrode/ filler wire extension by the stick-out length influence the burn- off rate and the weld bead profile. Welding current and voltage are related to the electrode stick-out length. A higher stick-out means a higher voltage and hence a wider weld profile. Same, time the welding current will be decreased and indirectly affects the depth of penetration and melt-off As defined by the American Welding Society (AWS), this refers to the length from the end of the contacttip to where the wire melts off. Rate. ***(Source:** google)*

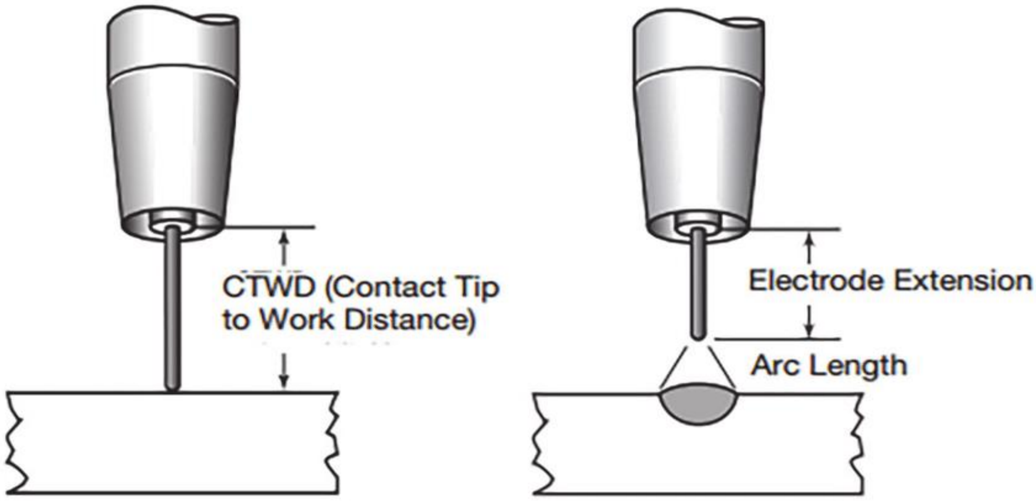

Fig: Stick-out length
(Source: https://www.researchgate.net/figure/Contact-tip-to-work-distance-and-electrical-stick-out-or-electrode-extension_fig3_347855952)

II. LITERATURE REVIEW

2.1 GTAW of Austenitic Stainless Steel

Neelam vilash sinde et al. has attempted to study the effect of alternate supply of the shieldinggas in comparison with the conventional method of TIG welding with pure argon gas. The two sets of combination are used as 10–10 and 40–20 s for alternate supply of the Argon and Helium shielding gas respectively. The effect of alternate supply of shielding gas is studied on the mechanical properties like bend test, tensile test and impact test. The full factorial experimental design is applied for three set of combinations. The ANOVA is used to find significant parameters for the process and regression analysis used to develop the mathematical model. The result shows that the alternate supply of the shielding gas for 10–10 s provides better result for the bend, tensile and impact test as compared with the conventional argon gas and the alternate supply of 40–20 s argon and helium gas respectively. Welding speed can be increased for alternate supply of the shielding gas that can reduce the total welding cost. The alternate supply of argon and helium shielding gas for 10–20 s provide good result for tensile strength, bend test, and impact test as compared to pure argon gas. Alternate supply of shielding gas can increase production rate and solves the problem of high cost of gases [7].
Ramkishor et al. has analyzed GTAW process in the fusion welding for joining different metals. Different fusion welding processes have varying degree of thermal impact affecting the characteristics of weld. The study

reveals the physical realization of basic understanding and scientific knowledge gathered from the observations. The study focuses attention on thermal characteristics these processes and their critical effect on microstructure and hardness of weld and HAZ. Above studies shows that P-GMAW process has the capacity to control the amount of heat transfer to the weld pool by varying mass of deposition which gives the finer weld microstructure, less inferior HAZ area and better mechanical properties of weld joint in comparison to that in GTA and SMA welding processes. [8].

V.Advaith et al. has attempted in this article investigates the properties A-GTAW weldments produced full penetration joints with lower heat input than the pulsed GTAW weighments. The tensile, impact, bend and hardness properties are evaluated in the weldments and compared. This article also elucidates the correlation between the microstructure and the properties. A study of PGTAW and A-GTAW joined by 316L SS & Hastelloy has been conducted to determine the penetration effect and mechanical properties of the two materials used for this joint. The study also examined the impact strength, tensile test, impact test and bend test of the welds as well as their conductivity. [9].

V, Anand Rao et al. This work aims at the analysis and optimization of joining similar grades of stainless steel by TIG welding. The parameters like current, filler materials, welding speed are the variables in the study. Welding current 120A and electrode 309L has produced greater tensile strength of 454.6MPa for the specimen studied. In bend test the same welding current with electrode 347 has produced minimum bending strength of 211.37MPa. Ultrasonic test results showed defects of penetration, but in general results indicate that the defect does not make an impact. [10].

Cherish mani et al. attempted has been made to analyses the tensile testing of 316L stainless steel Monel 400 gas tungsten arc welded joints. Process parameters considered for the study are filler materials and bevel angle used for butt joints. Transient structural analysis has been used for simulation. The results agree to a greater extent till the ultimate tensile region. Finite element simulation of tensile testing of Monel/SS 316L has been performed using transient structural analysis. The weld material ENiCrFe5 has higher strength than the filler wires made up of the base materials.

The increase in bevel angle decreased the linearized stress. FEM simulation can be used for prediction of stress-strain curves. [11].

Yelamasetti Balram et al. has used Infra-Red thermography to capture the surface temperature during welding processes. The nature of thermal fields and residual stresses were observed in both TIG and pulse TIG weldments of AISI 316 stainless steels. The IR images were captured at time intervals of 12 s, 25 s and 45 s and were analyzed using computer software. The maximum tensile nature RS value was observed in TIG welding process which could be reasoned to accumulation of more heat at the weld zone due to resistance of heat. The induced stresses were minimized by maintaining pulse arc mode and low frequency (4 Hz). IR thermography was found to be efficient temperature measuring tool for both TIG and pulse TIG processes. [12].

M. Anuradha et al. has done research on the weld zone of the Inconel 718 has an austenitic microstructure with secondary phases. The hardness of the weld zone varies due to the presence of secondary phases in the weld zone. The selected filler metal has good compatibility with the high- strength steel base metal to obtain a high-quality weld. The joint failure of the AISI4140 and Inconel 718 alloys, which were welded successfully using the TIG welding process, has led to a number of important conclusions. The maximum strength obtained at a welding current is 130 A and the joint fails in the weld zone and Actonel-Inconel fusion boundaries with the mixed mode of the failure. [13].

Shaonig Geng et al. has attempted GTAW on Austenite was harder than ferrite from weld metal to fusion line, while it reversed from fusion line to base metal. Electrochemical measurement indicated the zone containing fusion line was the easiest to suffer pitting attack, followed by the weld metal zone. The microhardness was determined by the partitioning of alloying elements (Cr, Mo, Ni and N) and precipitates such as chromium nitride. The microstructure, microhardness and behaviour in different zones of a 2205 DSS weld joint were investigated. High austenite content in zone 1 owes to formation of intragranular Austenite and secondary ferrite grains, while fine ferrite is formed near the fusion line in zone 2. Zones 3–5 have the similar macrostructure with base metal, but the volume fraction indicatesa downward trend. [14].

J.R. Deepak et al. has performed a detailed study of experimental and Computational analysis of properties. of the Heat Affected Zone in a Corten A588 steel when it is welded in Gas Metal Arc Welding (GMAW) without the edge preparation process and the ER70S-6 as filler wire. The model is created in CREO, and the analysis is carried out in ANSYS. The Highest Vickers hardness number (HVN) occurs at the Weld Zone whereas the

lowest HVN occurs at the Heat Affected Zone. When a heat flux of and is applied on the Weld surface, a distortion of 0.725mm is observed on both ends weld length and a maximum residual stress of 1365.3 MPa is observed. It can be observed that the average Heat affected zone width and. Weld width for the Corten Steel is 1.30 mm and 6 mm respectively, when specimen is welded. [15].
Balaram Yelamasetti et al. has studied about Dissimilar welds of Monel 400 and AISI 316 are extensively used in boiler feedwater heat exchanges, petrochemical industries and nuclear industries where moderate weld strength and high corrosion resistance are required. Tungsten Inert Gas (TIG), pulsed TIG and Interpulse TIG welding techniques have been tested for their ultimate strength and tensile properties. X-ray Radiography Test (XRT) has determined the macro/micro defects in the welds made of these materials. Tensile properties of TIG, pulsed TIG and Interpulse TIG weldments have been superior to that of other two welding techniques. Joints between Monel 400 and AISI 316 were free from micro/macro defects. Ni-based filler ERNiCrMo-3 most suitable for joining base metals by using TIG welding techniques. The weld strength of Interpulse TIG weldments is improved by 7.1% and 5.3% when compared to that of TIG and pulsed TIG joints. [16].

K. Devendranath et al. The use of flux containing 85% SiO2–15% TiO2 acquainted for better depth of penetration compared to autogenous welding. Segregation of Mo rich phases was witnessed in the fusion zone of flux assisted AISI 904L. Tensile studies showed that the fracture occurred at the fusion zone for both the weldments. Ductility was found to be greater for the flux-assisted weldments than for the autogenous ones. The use of compound flux, SiO2–TiO2 had considerably increased the depth of penetration, almost thrice than that of without flux ones in the same condition. Tensile failures occurred at the fusion zone of flux-assisted or non-flux-assisted GTAW and AISI 904L weldments. Autogenous weldments without flux additions demonstrated better impact toughness compared to those with flux. [17].

Gurudutt Ghadi et al. has performed this project work for Analysis of TIG parameters of Stainless Steel used in manufacturing of Heat Exchanger and Pressure Vessel. Stainless steel specimen (SS 202) of 6mm thickness used in the manufacturing of heat exchanger and pressure vessel is selected. Full factorial Design method is used to rank the welding parameters and predict tensile strength, bending strength and BHN. In manufacturing of heat exchangers and pressure vessels, a good strength weld joint is required. The weld joint of the shell as it is being rolled, re-rolled during manufacturing, it must withstand high tensile strength, bending strength and. Hardness of the joint found higher value for maximum current, Inert gas and diameter of the filler wire. Graphs obtained from full factorial design; it can be concluded for better performance. This project uses base material as stainless steel of SS 202, which is used in heat exchanger and pressure vessel. This can be extended for other materials such as Capron, super duplex and for the cladded materials. It can be further studied for the other NDT methods such as radiographic testing, ultrasonic testing etc for better analysis. [18].

J. Shivkumar et al. performed experiment of Cir Seam welding (GTAW) of aluminum alloy tube is simulated. The temperature distribution in the girth welded joint of AA6061-T6 tubes is evaluated. This result is used for estimation of residual stress and distortion due to welding. These are the major sources for weld crack and must be minimized by controlling weld heat. The heat source was developed for the simulation of the heat affected zone. Simulation is sensitive to parameters like efficiency (η), distribution parameters (a, b and c) and is to be simulated as far as possible to match experimental values. The temperature distribution obtained from this simulation is used for computation ofresidual stresses and distortion by coupled field analysis. [19].

Shivraman Arunkumar et al. performed study that focus on finite element simulation of gas tungsten arc welding (GTAW) of AA2219 aluminum alloy and the behavioral of the microstructure before and after weld. The simulations were performed using commercial COMSOL Multiphysics software. A fair copper rich cellular (CRC) network existed in the weld region as well as a small number of intermetallic compounds like Al_2Cu is observed through the XRD pattern. XRD patterns revealed that Aluminum was a major phase, and a small amount of Al_2Cu was observed in the weld metal. [20]

2.2. Effect of Activating flux over Mechanical and Metallurgical properties of Stainless Steel

Memduh Kurtulmus et al. has worked on Activated Flux TIG Welding of Austenitic Stainless Steels. The TIG welding with active flux (A-TIG welding) consists in depositing a thin layer of flux on the work piece surface just before the welding. It is found that with this process it is possible to increase the weld penetration and productivity up to three times higher or more compared to the TIG process in metals. In this review paper, A-TIG welding of austenitic stainless steels is examined. The welding flux, the shielding gas and the welding parameters affect the weld penetration in A-TIG welds. The effects of the activated flux welding mechanisms, the flux chemical composition, thickness of the flux, flux powder size welding current, the arc voltage, the arc length, the welding speed and composition of the shielding gas on weld geometry of austenitic stainless-steel A-

TIG welds are explained in detail[21].

VIKESH et al. found that in effect of A-TIG welding process parameters on penetration in mild steel plates. TIG welding is mostly used to weld thin sections for high surface finish. A major drawback in the processes having very small penetration as compared to other arc welding process. The problem canbe avoided by using active flux in conventional TIG welding. In the present study investigate the optimization of A-TIG welding process on mild steel for an optimal parameter by using Taguchi technique. The effect of various process parameters (welding current (I), welding speed (V), active flux) .IN the present study efforts were made to increase the weld penetration by applying the active flux and to optimize the process parameters [22].

2.3. Future Directions in Research on GTAW process.

As we see the current scenario moderate welding are not capable of performing the pressure vessel and leek proof joints. So, there are many advancements are done on GTA Welding process to meet the requirements. Dissertation work is carried out only for characterization of TIG welding process parameters such as current, inert gas flow rate and diameter of the filler wire. Further study is required for other parameters such as voltage, feeding rate of the filler wire, groove angle etc. This project usesbase material as stainless steel and its types which is used in heat exchanger and pressure vessel; this can be extended for other materials such as stainless steel, copper nickel, and super duplex and also forthe cladded materials. Testing of the specimen is carried out only for three types of tests; it can be further studied for the other NDT methods such as radiographic testing, ultrasonic testing etc. for betterjoint analysis as the products are utilized in pressurized industries. Due to Welding of the test piece distortions occurs the distortions induces stress in specimen. In future study heat treatment of the test to be carried out before it is used for testing and analyzing the test difference between the specimen which is heat- treated with specimen which is not heat-treated. [18]

III. CONCLUSION: -

Based on the reviews following interpretations are made: -

1.Tensile strength, hardness, impact resistance is influenced due to the different welding parameters.

2.Quality of weld mainly dependent upon the welding parameters used for the arrangement.

3. Proper selection of welding parameter can lead to the improved efficiency of weld, better economy and profitability.

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