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REVIEW PAPER ON PARAMETRIC OPTIMIZATION OF TIG WELDING

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ABSTARCT

Welding is the process of joining two or more similar or dissimilar metal by the application heat or sometimes pressure. Welding is a fabrication or sculptural process which is generally used to join the materials. Tungsten Inert Gas Welding (TIG) which is also known as Gas Tungsten Arc Welding (GTAW). The main objective of this review paper to understand and study the various components, equiptments used and the effects of the welding parameters such as welding current, gas flow rate, electrode angle, electrode etc are some inputs that directly affects the output parameters such as hardness, tensile strength, weld strength, quality of weld, microstructure.

KEYWORDS: TIG Welding, Electrode, Hardness, Tensile Strength, Welding Parameters.

I. INTODUCTION

TIG welding was developed during the second world war around 1940.Tungsten Inert Gas (TIG) welding is a strategy that involves using a tungsten electrode to heat the metal that is being welded. To protect the weld from contamination during the process, shielding in the form of inert gas, like argon, helium is used and can be used for any metals/thicknesses. TIG welding is highly regarded because of its quality and applicability. Indeed, the process can be applied to more metals than any other method, capable of welding metals like steel, bronze, nickel, brass, copper, magnesium, aluminum and gold. Welding in a TIG operation is very precise and clean, allowing for a superior appearance. This is because a welder can increase and reduce the amount of heat that is used in the process, by means of a foot pedal, in order to better control the weld. In terms of cleanliness, TIG welding doesn't result in sparks or create smoke and fumes.

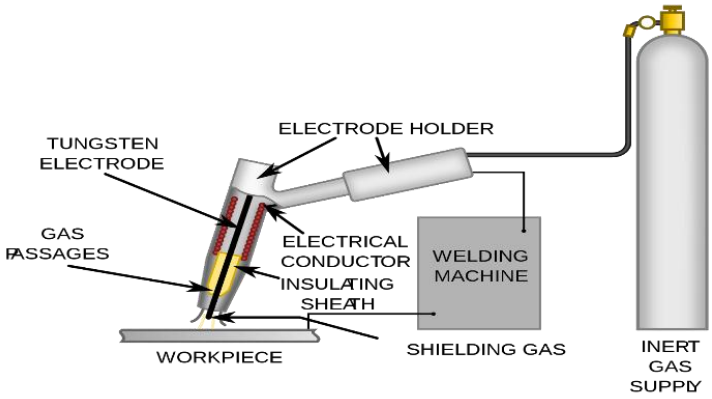

Fig-1: Diagram of TIG Welding Equiptment [8]

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1.1 Working Of TIG Welding:

During TIG welding, an arc is maintained between a long non consumable tungsten electrode and the workpiece is kept in an inert atmosphere (Ar, He or Ar-He mixture) to protect the weld from the atmospheric contamination and oxidation. Depending on the weld preparation and the workpiece thickness, it is possible to work with or without use filler. The filler can be introduced manually and automatically with regarding to types of process. The process itself can be manual, partially mechanized, fully mechanized or automatic. The welding power source delivers direct or alternating current.

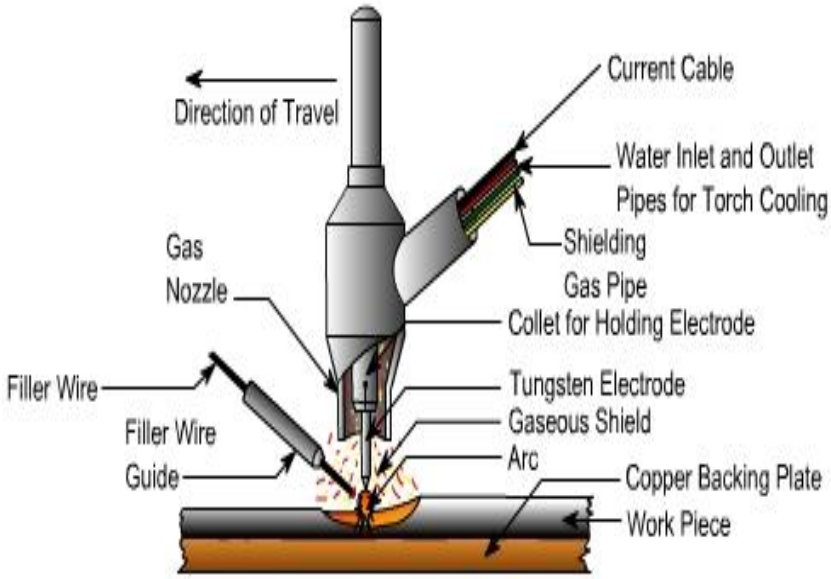

Fig-2: Working Principle Of TIG Welding[9]

1.2 Equiptments Used In TIG Welding:

- Welding machine
- Tungsten electrode
- Torch or electrode holder
- Filler metal rod
- Sheilding gas cylinder.

1.3 TIG Welding Parameters:

- Electrode Size
- Welding Current
- Arc Voltage
- Arc Travel Speed
- Stick Out
- Electrode Position
- Welding Position

1.4 Polarities:

There are three polarities used in TIG Welding process.

a. With direct current (DC) power supply, when electrode is connected with positive terminal and base plates with the negative terminal, then it is termed as Direct Current Electrode Positive (DCEP) or Direct Current Reverse Polarity (DCRP). So electrons liberate from base plate and flow towards electrode via the outer circuit. Continuous flow of avalanche of electrons in a small passage produces the arc (source of heat).
b. Opposite to DCEP, when the electrode is connected with negative terminal and base plates with the positive terminal, then it is termed as Direct Current Electrode Negative (DCEN) or Direct Current Straight Polarity (DCSP). So electrons flow from electrode to base plates. Consequently, more heat generates at the base plate as compared to electrode, so metal deposition rate reduces. Also various defects caused by insufficient fusion of base metal eliminate. But DCEN lacks cleaning action, so inclusion defects may arise if base plates are not cleaned properly prior to welding.
c. AC polarity offers advantages of both DCEN and DCEP; however, to some extent only. With AC power source, in half of the cycle electrode becomes negative and in next half of the cycle, electrode becomes positive. This cycle repeats 50 or 60 times in a second depending on frequency of supply (50Hz or 60Hz). Some power sources also provide provisions to alter this frequency.[10]

1.5 Electrodes Used In TIG Welding Process:

There are five types of electrode which is used in the TIG welding process which can be identified with the help of their colours.

- Pure Tungsten (W) (Green Colour)
- Zincronium Tungsten (Brown Colour)
- Striped Tungsten (Blue Colour)
- 1% Thoriated Tungsten (Yellow Colour)
- 2% Thoriated Tungsten (Red Colour)

1.6 Sheilding Gas Used In TIG Welding:

- Argon
- Helium
- Mixture of Argon and Helium

1.7 Advantages Of TIG Welding:

- Versatile and uses less energy than other welding methods.
- Produces high quality weld and stable arc.
- No slag is produced.
- No smoke or fume produced.
- No flux is required.
- Thermal distortion in the workpiece is minimal.
- Provide precise control of welding variables.
- Weld composition is close to that of the parent metal.
- Welding can be done in all positions.
- Especially good for welding of thin sections.

1.8 Disadvantages Of TIG Welding:

- Lower filler metal deposition rate.
- Brighter UV radiation than any other welding process.
- Equiptment cost tend to be higher than other process.
- Arc travel speed is slow.
- Need hand eye coordination to accomplish the weld.
- Tungsten inclusion is hard and brittle.
- Not suitable for thick sections.
- Highly skilled operator is required.

1.9 Application Of TIG Welding

1. **Aerospace** – Aircraft and spacecraft are constructed in part by means of TIG welding. So, the commercial planes used every day, as well as complex craft like the International Space Station have benefitted from such processes as TIG welding which is known for its strength and precision.
2. **Automotive** – Safe and secure construction is essential in the auto industry, as is making vehicles stand the test of time. For these reasons, TIG welding is widely used in the automotive industry. TIG strategies are known to reduce corrosion over time, so car fenders are frequently welded in this way to avoid rust. Besides this, the better the vehicle is constructed, the safer it will be for those travelling in it.
3. **Repair** – TIG may be used in a number of repair applications. From fixing a child's toy, like a wagon or old-fashioned pedal car, to repairing aluminum tools, this welding method comes in handy.
4. **Art** – TIG is touted for the superior cosmetic appearance it results in. Artworks are about the artist's message, yes, but they also rely on appearance. Therefore, works like industrial fixtures or metal sculptures may rely on TIG welding processes.

II. LITERATURE REVIEW

P Bharath.(2014) [1] performed the experiment Optimization of 316 Stainless Steel Weld Joint Characteristics using Taguchi Technique it has been observed that current, speed, root gap has some influence on the tensile strength and the bending strength of the material.

Based on Analysis of variance (ANOVA) it is found that welding speed (46.51% contribution) has greater influence on bend strength and current (96.75%) has highest influence on tensile strength. Further it has found that root gaps has some influence on both tensile and bend strengths.

Microstructure study shows some inclusion near heat affected zone due to change in weld materials and change in grain sizes that are developed during welding process.

Azadkumar Vegda.(2018) [2] performed the experiment Experimentation, Analysis and Optimization of TIG Welding Process for SS-316l, it has been concluded that current has major impact in affecting the output tensile strength and the groove angle has a least impact on the tensile strength.

Sanjeev Gupta.(2016) [3] carried out the experiment Optimizing Conditions for Performing GMAW (TIG) Welding on Ultra 904L Specimens and concluded that on varying the current and keeping the gas flow rate constant and observed that the welding joint is not made below 50A and above 200A , burning of the specimen started.

SR Patil ,CA Waghmare. (2013) [4] performed an experiment Optimization Of MIG Welding Parameters For Improving Strength Of Welded Joints, he concluded that welding speed has major influence on the tensile strength

of welded joints. A Taguchi orthogonal array, the signal-to-noise (S/N) ratio and analysis of variance (AVOVA) were used for the optimization of welding parameters.

Mr. R Ramchandra.(2015) [5] conducted an experiment Analysis And Experimental Investigation Of Weld Characteristic For A TIG Welding With SS316L he concluded that after performing various destructive and non destructive tests great effect of welding parameters such as welding current, voltage and gas flow rate on weld joint. For this Amps and voltage maximum depth of penetration is obtained with minimum failure is occurred.

Mr.L.Suresh Kumar , Dr.S.M.Verma , P.RadhakrishnaPrasad , P.Kiran kumar, Dr.T.Siva Shanker(2011) [6] Conducted an experiment Experimental Investigation for Welding Aspects of AISI 304 & 316 by Taguchi Technique for the Process of TIG & MIG Welding and concluded that the hardneass of the austenitic stainless steel when it is welded by TIG process then the hardness value (BHN) at 40A for TIG process is 162.3 and for the MIG it is 196.54. So from this he concluded that MIG process is suitable at low currents. He also concluded that the ultimate load of 57600N is bear by TIG welded specimen and MIG welded specimen can bear the ultimate load of 56160N. So we can say that the TIG welded specimen can bear more load than that of MIG welded specimen. He also concluded that on decreasing the speed and increasing the current then the heat affected zone is increases. And finally found that the parameters have good results in TIG welding and TIG welding is best for the austenitic grade materials.

Manik Gupta, Sanjeev Kumar Shukla, Vipin Kumar Sharma, Hermant Kumar (2018) [11] conducted an experiment Effect Of TIG and MIG Welding On Microstructural and Mechanical Properties : A State Of Art and explained that welding parameters such as welding speed, welding voltage, welding current, etc have a considerable effect on the properties of the weldment. In this he performed the tensile strength and impact strength test on weldment of A-6061 by TIG welding and the better quality of tensile strength and impact strength of the weldment is produced whereas for A-6062, MIG should be preffered due to favourable grain structure.On varying the bevel angle for MS IS 2062 ultimate strength and yield strength varies and on increasing the current and voltge there is the increasement of yield strength and uts. It is also observed that properties are largely dependent on base metal and process used.

Javed Kazi, Syed Zaid, Syed Mohd. Talha, Mukri Yasir, Dakhwe Akib (2015) [12] performed an experiment A review On Varioius Welding Techniques and concluded that the as decreases the speed and increase the current then the heat affected zone is also increases.On the basis of their result he also concluded that hardness of MIG welding is greater than TIG welding. Ductility is also higher in MIG weldingas compared to TIG welding. TIG welding specimen can bear more load, yield stress and tensile strength.On the basis of the result all the parameters in TIG welding is better and best for steel.

Akash B Patel, Prof Satyam P Patel (2014) [13] performed an experiment The Effect of Activating Flux in TIG Welding and concluded that the most of the welding parameters like welding flux, welding current, welding speed, depth to width ratio generally used in the research work. TIG welding carried out on different materisla like MS,Titanium alloy, brass, carbon, stainless steel etc. He also find out welding penetration, depth to width ratio, strength of welding joint by the theoretical equations and experimentally measure with the help different input parameters. For achieving the result of experimental work and the study of various journal the austentic type stainless steel with grade E321is selected and fluxes are SiO2andTiO2.

I.J Rohit, R. Ajithraj and M. Dev Anand (2017)[14] performed an experiment on Experimental Analysis of TIG Welded 304 Stainless Steel Using Artificial Intelligence Tool and concluded that the research reveals the successful use of AI based on the Adaptive Neuro Fuzzy Inference System for the prediction of the tensile strength of the TIG welded AISI 304 stainless steel specimens and the obtained result indicate the accuracy over other prediction concept.The average tensile strength of the specimen is 638.5185MPa.However the maximum tensile strength

obtained is 664MPa fot the corresponding process parameters are voltage 12V, Welding Current 50A, Gas flow rate 12litre per metre and speed 1mm per minute.

D. Venkata Krishna, E. Mahesh, G. Kiran, G. Sai Suchethan, G. Chandra Mouli (2016) [15] performed an experiment Numerical Analysis on the effect of welding parametres in TIG welding For INCONEL 625 alloy and concluded that the plates of 50mmx50mmx3mm are modelled and assembled it for v butt joint on solidworks and then this model is imported in the FEA software(ANSYS) to carry out the transient thermal analysis.The analysis is carried out with the combinations of different welding parameters such as voltage, current, velocity, speed and melting efficiency.And he also explained the length of heat affected zone for the variation of different welding parameters.

C. Selva Ganesh, Dr.T. Vigraman, D. Sujith, M. Velmanikandan, T. Vetrivel (2017) [16] conducted an experiment Microstructural and Transient Thermal Analysis of TIG Welded Joint SAE 2205 With AISI 304 With AISI 308 Filler Metal and concluded that the maximum tensile strength of 549MPa was obtained when the sample was processed at 130A. Maximum hardness of RC 36 was observed at the base metal SAE 2205 side for the sample which is welded at 130A and on increase in the hardness values were attributed to presence of the more amount of chromium and sigma phase in the base metal SAE 2205. In all the samples ultra fine grains and fine grains were formed at the HAZ zone. And maximum Von Mises stress of 85MPa is obtained at the weldment which is made between SS AISI 304 and SS SAE 2205.

Prashant Sagar (2018) [17] performed an experiment on Thermal Analysis of TIG welded Ti-6AI-4V plates using ANSYS and concluded that on study of ANSYS temperature profile he found that the heat affected zone is more at lower speed of welding (3mm/sec) specimen and very less at the higher speed (6mm/sec) because of high heat concentration at the low speed. And he also concluded on the basis of study of graph that with the increment in welding speed temperature decreases.

D.Devakumar, D. B Jabaraj (2014) [18] conducted an experiment on Research on Gas Tungsten Arc Welding Of Stainless Steel-An Overview. For Welding AISI 304 Stainless STEEL using GTAW process it is recommended to have low input of heat in order to provide good tensile strength and ductility and the heat effected zone and grain coarsening obtained in weld joint is less.Hardness is less in HAZ region in comparison to the weld metal and base metal regions.The enhancement strength value obtained by GTAW process is about 10% of SMAW joints and 20% of GMAW joints. On increasing the current the Bowing distortion increases.

Sreejith.S. Nair, K. Vijayakkannan and N .Karunaraja (2016) [19] performed and experiment on TIG Welding using external Magnetic field and concluded that magnetic field plays an important role in improving the mechanical properties of the similar metal using TIG welding with the help of the magnetic field toughness of weldmend increases to 6.25% in Izod test and 13.63% in Charpy test and Hardness of the weld metal increases to 3.61% in Rockwell harness test and 7.40% in Brinell hardness test.

M. Uthayakumar, V.Balasubramanian, Ahmad Majdi Abdul Rani, Branislav Hadzima (2018)[20] performed an experiment Effects Of Welding On The Fatigue Behaviour Of Commercial Aluminium AA-1100 Joints and concluded that the FSW joint have higher properties than the MIG and TIG joints. The FS welds have yield strength 91.30% of base metal while the MIG and TIG have 90.7% and 88.9% of that of the base metal. It is also found that the FSW welding process has yield strength 1.3% higher than that of MIG and 2.4% to that of TIG process.And many other mechanical properties is better than that of MIG and TIG welding. In fatigue test for the notched joints FSW process has about 88.88% of klife of the base metal. The TIG process has 77.75 and the MIG process has 66.6% of the life of the base metal. The FSW shows that there is an increment of 11.1% over TIG and 22.2% increment over MIG process.

A. Balaram Naik, A.Chennakesava Reddy (2016) [21] performed an experiment on the Experimental Analysis of TIG Welding and Comparison between A-TIG and TIG on Duplex Stainless Steel (2205) and concluded that the effect of various input parameters on certain performance measures by using Taguchi's Orthogonal array experimental design on DSS 2205.He conclude that time and current play an importamnt role on the tensile strength, tensile strength is maximum at 180sec and 250A but at low gas flow rate.Hardness is also mainly affected by the current and it is maximum at 250A, 150 Sec and 6L/min.

Akshansh Mishraa, Anish dasgupta (2018) [22] performed an experiment Low Cycle Fatigue Analysis of Friction Stir Welded And TIG Welded AL-MG-SI Alloy Similar Joints and concluded that 4mm thick AA6061-T6 aluminium alloys were welded successfully using FSW and TIG welding for similar alloy pair. Tensile test shows FSW joints have higher strength and higher ductility as compared to TIG joints. AA6061-T6 aluminium alloy welded by FSW method has greater fatigue life as compared to same alloy when welded byTIG welding process.

Sreejith Mohan, Boby George, Akarsh A, Amal Mohan P, Sharan C.P, Sheryas A (2016) [23] performed an experiment Structural Analysis of TIG generated chromoly welds and concluded that when metals are Welded under same parameters they seems to have Chromoly the same tensile strength. Micro hardness of Chromoly is greater than mild steel. The microstructure analysis has shown that Chromoly has more refined grain structure than mild steel which provide it advantage of being more malleable and ductile.

Vijay Gohel, Jatin Makwana, Riteshkumar Ranjan (2016) [24] has conducted an experiment on Thermo-mechanical analysis in TIG welding of S.S 304and concluded that there is a close agreement between the simulation and experimental thermal profile. There are various experimental methods for measuring temperature developed during welding but they are costly and time taking so in order of getting better result with least variation in experimental results FEM is being used where welding applications deals with complex products.

MOI Subhas Chandra, PAL Pradip Kumar, BANDYOPADHYAY Asish, RUDRAPATI Ramesh(2018) [25] performed an experiment on DETERMINATION TUNGSTEN INERT GAS WELDING INPUT PARAMETRES TO ATTAIN MAXIMUM TENSILE STRENGTH OF 316L AUSTENITIC STAINLESS STEEL is that gas flow is not only affected by NTS but also by UTS, and in this respect welding current and welding speed are also an important factor. The micro hardness value of the weld metal is higher than those of the HAZ and base metal.It has been found that tensile strength of welded joints is higher than the base metals.

Aravinth .P , Subramanian .S.P , Sri Vishnu .G , Vignesh .P (2012) [26] conducted an experiment on PROCESS FAILURE MODE AND EFFECT ANALYSIS ON TIG WELDING PROCESS- A CRITICALITY STUDY is that the most risky defect in TIG welding is porosity and improper shielding is also a serious issue. Thus corrective action should be taken before welding and proper maintenance should be done for effective welding.

Aamir R. Sayed, Yogesh V. Kumbhare, Nikhil G. Ingole, Parvin T. Dhengale, Nainish R. Dhanorkar (2019) [27]conducted an experiment A Review Paper Of Dissimilar Metal Welds Of Stainless Steel and Mild Steel by TIG Welding Process and concluded that to optimized the welding output such as tensile strength, hardness of weld joints etc on varying the input parameters such as welding current, voltage, gas flow rate, welding speed etc.

Ashishkumar Wahule, Prof. Kushal Wasankar (2018) [28] performed an experiment Multi-response Optimization Of Process Parameters Of TIG Welding For Dissimilar Metals (SS-304 and Fe-410) Using Grey Realational Analysis and concluded that the optimum value for the tensile strength was observed as 120A of current , 16L/min of gas flow rate and 2mm of root gap. From ANOVA the maximum contribution was found of current i.e. 47.38% followed by gas flow rate i.e. 37.95% and root gap. The optimum value for percentage elongation was observed as 120A of current , 16L/min of gas flow rate and 1mm of root gap . From ANOVA the maximum contribution was found of current i.e. 62.88% followed by gas flow rate i.e. 24.08% and root gap.

Sanjay Kumar, Pravin Kumar Singh, Dharmendra Patel, S. B. Prasad (2017) [29] performed an experiment Optimization Of TIG Welding Process Parameters Using Taguchi's Analysis and response Surface methodology and concluded that voltage is the most effective parameter for both hardness and for bending strength. The highest hardness has been obtained at 70 A (2^{nd} level of current) , 50 V (3^{rd} level of voltage), 0.5mm (1^{st} level of root gap) and 16 litter/min (1^{st} level of gas flow rate) . on the other hand highest bending strength is found at 2^{nd} level current , 1^{st} level of voltage, 1^{st} level of root gap and 3^{rd} level of gas flow rate.It has been found from the result of ANOVA that voltage is the most influencing factor for changing the mechanical properties of welded joints.

III. CONCLUSIONS

This paper gives an idea for performing the TIG welding and from this literature review it is clear that the various work has been already done on the TIG welding to study and optimization of the welding output such as hardness, microstructure, tensile strength, ultimate load of the weld etc by varying the input parameters like current, voltage , electrode angle, welding speed etc. TIG welding is widely use process for the fabrication of both similar and dissimilar materails.

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