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Joining of Microwave Components by Use in Gas Tungsten Arc Welding Process for Space Applications: A Review

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Abstract - *Microwave components plays a crucial role in communication system. To convey all types of information including likes voice, data links, wireless network, satellite and spacecraft communication system etc. One of the prominent microwave component extensive use in communication satellites is amplifier. Amplifier is one of the major component use in payload of communication satellites. During work fabrications of microwave components, joining of microwave components, and testing of microwave components welding joints. During work, Fabrication of components of amplifier has performed using high precision Lathe machines. A special focus is given for development of circumferential edge Joint process of microwave components by use in Gas tungsten arc welding and Plasma arc welding process in Kovar, Monel-404, and Soft iron types microwave components materials and states necessary fixture use during welding for joining of microwave components. The welded joints have developed for leak proof joint and should be able to sustain vacuum pressure of the order of 10^{-11} Torr. During work study of Gas tungsten arc welding and Plasma arc welding process parameters such as welding current, voltage, electrode work piece distance, duty cycle, gas flow etc. During work-study of number of non-destructive test and after conducting various non- destructive test, like visual inspection, X-ray test, die penetration test and special focus on Helium leak proof test.*

Key Words: Space qualified material, Gas tungsten arc welding, Non-destructive tests, and Space applications.

1. INTRODUCTION

Welding is a permanent joining process used to join different types of materials like metals, alloys or plastics. During welding, the work-pieces has joined are melted at the interface and after solidification; a permanent joint can be achieved. Sometimes a filler material is use to form a weld pool of molten material. Filler material provide good welding strength during weld joint. Weld ability of a material depends on different factors like the metallurgical changes, welding parameters and welder skill dependent during welding.

1.1 Basic mechanism of Gas tungsten arc welding process

Gas tungsten arc welding process also called Tungsten inert gas welding process (TIG). Gas tungsten arc welding process developed during 1940 at the start of the Second World War. Gas tungsten arc welding process has generally done with a single electrode but multiple electrodes are sometimes used. The weld area is protected from atmosphere by an inert shielding gas (argon or helium), and a filler metal is normally used. Filler metal provide good welding strength when work piece size is thick. The power has supplied from the power source (rectifier), through a hand-piece or welding torch and delivered to a tungsten electrode, which has fitted into the hand piece. The tungsten electrode and the welding zone have protected from the surrounding air by inert gas. The electric arc can produce temperatures of up to 20,000 Degrees Celsius and this heat focused to melt and join two different part of material. The weld pool used to join the base metal with or without filler material. Schematic diagram of Gas tungsten arc welding and mechanism of Gas tungsten arc welding process are show in fig.

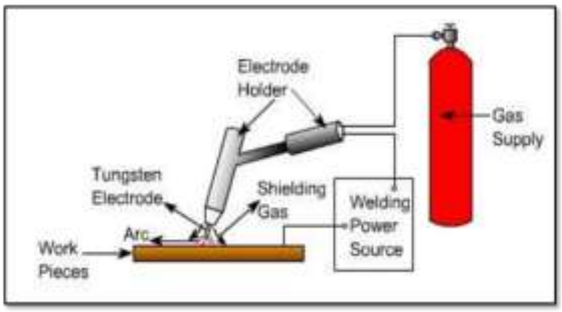

Figure 1: Schematic Diagram of Gas tungsten arc welding System.

The current carrying capacity of each size of electrode depends on whether it has connected to negative or positive terminal of DC power source. The capacity to limit the current to the set value is equally crucial when the electrode has short-circuited to the work piece, otherwise excessively high current will flow, damaging the electrode. Open circuit voltage of power source ranges from 60 to 80 V.

1.2 Effect of Process parameters in gas tungsten arc welding

- *Welding current*
- *Filler material*
- *Electrode Vertex Angle*
- *Electrode Work Piece Distance (mm)*
- *Welding speed*

- *Shielding gas*
- *Duty cycle*

1.2.1 Types of welding current used in Gas tungsten arc welding process are:

DCEN (Direct Current electrode negative):

Gas tungsten arc welding direct current is used. These types of welding current also called direct current straight polarity. Tungsten electrode has connected to the negative terminal of power supply. A 70% heat generate in work piece and 30% heat generate in electrode. This type of welding current provides higher penetration and higher welding speed. These types of welding current use in higher thickness components.

DCEP (Direct Current electrode positive):

Gas tungsten arc welding direct current is used. These types of welding current also called direct current reverse polarity. Tungsten electrode has connected to the positive terminal of power supply. A 70% heat generate in electrode and 30% heat generate in work piece. This type of welding current provides lower penetration and lower welding speed. These types of welding current use in less thickness components.

AC (Alternating Current):

These types of welding current suitable for whitest metals, Aluminum and magnesium. Gas tungsten arc welding also use alternative current. Tungsten electrode has connected to one-half cycle positive and second half cycle negative. A cycle is alternative rotating so is current name is alternative current. A 50% heat generate in electrode and 50% heat generate in work piece. This type of welding current provides medium penetration and medium welding speed. These types of welding current use in Suitable for welding of Aluminum & Magnesium alloys because they have very stable oxides.

2. Amplifier Microwave components materials

There are different types of materials used in fabrication of amplifier components. Gas tungsten arc welding process has performed at materials like Kovar, Monel-404 and soft iron.

Kovar: Kovar use for fabrication of amplifier components because of its unique property of thermal expansion. The coefficient of thermal expansion of Kovar is $5x10^{-6}$/K for temperature range of 30^0C - 200^0C.

Monel-404: Monel 404 alloy used for fabrication of amplifier components because it has used primarily in specialized electrical and electronic applications. The composition of Monel 404 alloy is providing to a very low Curie temperature, low permeability, and good brazing characteristics. Monel 404 can be welded using fusion welding techniques but not has been used hot worked. Monel 400 series alloys good machinability and provide good weld joint.

Soft Iron: Soft Iron use in fabrication of amplifier components because it is a low Carbon content ferrous alloy and finds its extensive use in amplifier components because it can be easily magnetized or demagnetized.

3. Advantage of Gas tungsten arc welding

1. Tungsten inert gas welding process provide narrow concentrated arc.
2. A welding process able to weld ferrous and non-ferrous metals.
3. Gas tungsten arc welding weld should have no spatter.
4. Gas tungsten arc welding provide stronger joint compare to shield arc welding.

4. LITERATURE REVIEW

Chandrakanth et al. (2014) [1] studied the effect of welding parameters on mechanical properties of gas tungsten arc welding process used in material SS316L. SS316L selection of material grade because of its lower carbon content and good weld ability properties. The welding parameters are selection of Taguchi's L9 orthogonal array with varying gas flow, current and bevel angle with the predictions achieved the sample is welded. The level of importance of welding parameters for tensile strength is determined by using analysis of variance (ANOVA). Weld joint testing use in non-destructive test like radiography inspection and microstructure test has performed on samples, which showed low, medium, and high tensile strength in order to view the changes occurred after welding.

S. Arunkumar et al. (2015) [2] has conducted his research work on a Aluminium alloy AA2219 type material used because is a high strength alloy belonging to 2000 series. A material grade widely used in aerospace applications, especially for construction of cryogenic fuel tank. Gas tungsten arc welding process apply in AA2219 type material is very critical. 25mm thick AA2219-T87 plate butt welded by use in tungsten inert gas welding and gas metal arc welding process using multi-pass welding procedure in double V groove design. The researcher observed mechanical properties like transverse shrinkage, and metallurgical properties. Further, it has noticed that, the severity of weld thermal cycle near to the fusion line of Heat effected zone has reduced due to low heat input in tungsten inert gas welding process. Researcher has study to both mechanical and metallurgical properties is inferred that tungsten inert gas welding process is used to improve the characteristics of weld joints in comparison to Gas metal arc welding process.

M. Manikandan et al. (2014) [3] has conducted his research work on a Nickel based super alloy C-276 type material used. A researcher optimizes Pulsed Current Gas Tungsten Arc welding process parameters of alloy C-276 by use in the Taguchi method have employed to bead on welding trials to A L9 orthogonal array of Taguchi design involving nine experiments for four parameters. Four parameters include in Taguchi method like pulsed current, background current, percentage on time, pulse frequency with three levels has used. The optimum conditions has found to be 165 A pulse current, 77 A background current, 60 % on time and 5 Hz pulse frequency. Analysis of Variance (ANOVA) has performed to measure percentage contribution of each factor. The researcher has observed that the pulse current was most influencing parameter on the depth of penetration and 23.28 % on time the next most influencing. Researches has shown the result that is good match between expected and predicted results.

N. Ramakrishnan et al. (2016) [4] studied the effect of welding parameters on mechanical properties of gas tungsten arc welding process used in material AA6063. Researchers has study to process parameters like weld current, gas flow and work voltage on the Bead Geometry of the welded joint. Researchers has that observed during experimentation it has found that, increase in the welding current result in increase in heat input. Researcher has observed that as thickness of the work piece increases rate of gas flow need to increase-to-increase the heat diffusion rate and increases the penetration. Researcher has increase in weld current and gas flow so a result is change in Bead Geometry of the welded joint, which dominates the weld characteristics. The variations in the process parameters affect the mechanical properties with great extent. Researcher has testing of final weld joint by use in destructive and non-destructive test like hardness test, ultrasonic test.

K. Devendranath Ram Kumar et al. (2015) [5] has conducted his research work on a marine grade alloys Monel 400 and AISI 904L material used. Joining of marine grade alloys Monel 400 and AISI 904L by use in by pulsed current gas tungsten arc welding (PCGTAW) technique using ERNiCu-7 and ERNiCrMo-4 filler metals. Microstructure studies corroborated the formation of migrated grain boundaries at the fusion zone of ERNiCrMo-4 weldments. Researcher also observed that partially melted zone (PMZ) weld interface of Monel 400 while using ERNiCrMo-4 filler. Tensile studies corroborated that the joint strength has found better for the ERNiCu-7 weldments compared to ERNiCrMo-4 weldments. The outcomes of the present study will be beneficial to the industries operating these metals.

C. Chen et al. (2017) [6] has conducted his research work on an aluminium alloy material used. Researcher has main work increasing gas flow by use in arc diameter and area were compressed. Gas tungsten arc welding process use in join of aluminium alloy by use in direct current electrode negative. Researcher has observed that oxidation film decreased with gas flow rate increasing. Helium Gas flow rate is 5 to 20 L/min. Generate Compression effect because Penetration increased with gas flow.

Sadu Venkatesu et al. (2018) [7] has conducted his research work on a 316 stainless steel used material and apply three welding process during work. A welding joint is thin so use fusion welding proceeds in work. Welding process name are Laser Beam Welding, Gas Tungsten Arc Welding and High Temperature Brazing methods. A welding joint have been made and inspection of weld joint by use in non-destructive test like helium leak test and destructive test use in inspection of weld joints. Researcher has study been performed on these joining techniques to recognize the suitable method for high temperature applications. Result have been observed that Laser beam welding joints have better mechanical properties than Gas tungsten arc welding joints and High temperature brazing joints.

R. Sudhakaran et al. (2014) [8] has conducted his research work on a Chromium-Manganese Stainless Steel used Material apply in Gas tungsten arc welding process. Welding parameters such as welding speed, welding current, welding gun angle and gas flow rate has developed. Researcher has work Central composite response surface methodology with four parameters and five levels was employed for conducting the experiments and used the adequacy of the developed model was checked using ANOVA. Weld quality of the weld joint is also highly influenced by the microstructure of the weldment. Researcher also investigates the influence of welding gun angle on the microstructure examination of the weldment. The microstructure study concentrated on the grain structure, presence of carbides and formation of ferrite, austenite and marten site in the weldment. Result researcher has also observed obtained from the present investigation helps in quickly selecting the required process parameters to achieve the desired Pitting resistance equivalent number and weld quality.

P. Naveen Kumar et al. (2014) [9] has conducted his research work on an ultra-high strength steel material used likes 15CDV6 steels and SAE 4130 steels are widely used because of their high strength material. A steel material is difference to other steel alloy compositions. Researcher has work to 3mm thick 15CDV6 alloy steel sheets were joined to SAE 4130 low alloy steel by use in inter pulse gas tungsten arc welding process using 8CD12 alloy filler wire. Different welding parameters and heat treatment cycles has employed. Final weld joint Test by use in performed during research work non-destructive test likes dye penetrant test and X-ray radiography test use in check of weld quality. Gas tungsten arc welding process has performed successfully to join low alloy steels SAE 4130 & 15CDV6 by using 8CD12 filler wire.

Aravinda Pai et al. (2014) [10] has conducted his research work on a modified 9cr-1Mo used material for construction of steam generator. Researcher has study to mechanical properties such as tensile strength, hardness, impact toughness at +18 degree Celsius welds produced by the gas tungsten arc welding process. Researcher has observed by microstructure of weld joint by used in gas tungsten arc welding process and various mechanical properties modified by use in hot and cold wire gas tungsten arc welding process. The fabrications of steam generator has carried out by combination of hot wire and cold wire tungsten inert gas welding process.

G. Madhusudhan Reddy, K. Srinivasa Rao (2014) [11] has conducted his research work on a Superior property of maraging steels used material for the fabrication of components used for military applications like missile covering, rocket motor casing and ship hulls. Gas tungsten arc welding process used in fabrications of maraging steels components for use in military applications. These research paper study is aimed the stress corrosion cracking (SCC) behaviour of MDN 250 (18% Ni) steel and its welds with respect to microstructural changes. Welding joint plate thickness is 5.2 mm sheets made of MDN 250 steel in the solution-annealed condition has welded using Gas tungsten arc welding process. Researcher has final job observed that Stress corrosion cracking resistance was found to be highest for marging steel welds after the post weld heat treatment condition of homogenization.

P. Paulraj, R. Garg (2016) [12] has conducted his research work on a duplex stainless steel (DSS) and super duplex stainless steel (SDSS) materials used. Gas tungsten arc welding process use in joining of duplex stainless steel and super duplex stainless steel pipe. Researcher has studied welding parameters like heat input, inter-pass temperature, cooling rate, shielding gas, on corrosion behaviour. After welding, the weld joints testing by use in non-destructive test. Researcher has also observed final weld joint to ensure no defects and test samples were prepared for microstructural examinations and ferrite content measurements. DSS weldments had Critical pitting temperature in between 23 °C to 27 °C and SDSS weldments had Critical pitting temperature between 37 °C to 41 °C in potentiostatic measurements. Tungsten inert gas welding process performed successfully on DSS and SDSS pipes. A final test of weld joint result is corrosion mechanical properties improve at low heat input, low inter pass temperature, higher shielding gas and fast Colling rate.

J.R. Joshi et al. (2016) [13] has conducted his research work on an AISI 4130 steel material used. Researcher has included Two welding process in research work. Tungsten inert gas welding and laser beam welding process use in joining of dissimilar steel welds has characterized through optical microstructures, micro hardness survey across the weldment and evaluation of tensile properties. Researcher has observed that weld joint and output is fibre laser beam welds good have demonstrated superior mechanical properties and reduced heat affected zone as compared to the gas tungsten arc welding weldments.

Sanket C. Bodkhe et al. (2016) [14] has conducted his research work on a stainless steel alloy 304L type material used in research work. Tungsten inert gas welding process use in weld joint. Researcher has studied to input parameters like welding current, welding speed, arc gap, and design of experiments has carried out using central composite design of response surface methodology and studied the influence of input variable on design of penetrations. Researcher has also use in ANOVA and RSM methods was carried out to determine the significance of the process parameters and it is found the welding current is the most significant input variables and also used for numerical optimizations to obtain maximum depth of penetrations.

5. CONCLUSION

Kovar, Monel-404, and Soft iron type materials widely used in space applications, aerospace and aircraft industry because of their certain suitable property like high thermal conductivity, high melting point, high corrosion resistance, and good weld ability. To fabrication thin (0.5 mm thickness) amplifier components and joint all components by use in gas tungsten arc welding process has been produced defect free, leak proof material joints as compare to other fusion welding process.

REFERENCES

1) **Balaji Chandrakantha, S. V. Abinesh Kumarb, S. Ashwin Kumarc, R. Sathishd** “Optimization and Non-destructive Test Analysis of SS316L Weldments Using GTAW” 2013.

2) **S. Arunkumar, P. Rangarajan, K. Devakumaran, p. Sathiya,** “Comparative study on transverse shrinkage, mechanical and metallurgical properties of AA2219 aluminum weld joints prepared by gas tungsten arc and gas metal arc welding processes” 2015.

3) **Manikandan M, Nageswara Rao M, Ramanujam R, Devendranath Ramkumar a, Arivazhagan N, Reddy G. Mb** “Optimization of the Pulsed Current Gas Tungsten Arc Welding Process Parameters for alloy C-276 using the Taguchi Method” 2016.

4) **N. Ramakrishnan1, B. Chandra Mohan & S. Rajeshwaran** “Experimental Investigation and Predict GTAW Process Parameters on AA6063” 2016.

5) **K. Devendranath Ramkumar, Shah Vitesh Naren, Venkata Rama Karthik Paga,Ambuj Tiwari, N. Arivazhagan** “Development of pulsed current gas tungsten arc welding techniquefor dissimilar joints of marine grade alloys” 2015.

6) Chen Chena, Xinqian Weia, Yong Zhaoa, Keng Yana, b, Zhanjun Jiab, Yuxiang He "Effects of helium gas flow rate on arc shape, molten pool behavior and penetration in aluminum alloy DCEN TIG welding." 2017.

7) Sadu Venkatesu, M. Gangaraju, S. Bhaskar and B. Vishnu Vardhana Naidu "A Study of Laser Beam Welding, Gas Tungsten Arc Welding and High Temperature Brazing Processes on Micro hardness and Tensile Strength of AISI Type 316 Stainless Steel" 2018.

8) Sudhakaran. ra, Sivasakthivel. p.sb, Nagaraja.sc and Eazhil. k.md "The Effect of Welding Process Parameters on Pitting Corrosion and Microstructure of Chromium-Manganese Stainless Steel Gas Tungsten Arc Welded Plates" 2014.

9) P. Naveen Kumar, Y. Bhaskar, P. Mastanaiah, CVS Murthy "Study on dissimilar metals welding of 15CDV6 and SAE 4130 steel by inter pulse gas tungsten arc welding" 2014.

10) Aravinda pai, Irappa Sogalad, S. K Albert, Prabhat kumar, T. K Mitra, and S.Basavarajappa "Comparison of microstructure and properties of modified 9Cr-1Mo weld produced by narrow gap hot wire and cold wire gas tungsten arc welding" 2014.

11) G. madhusudhan reddy, K. Srinivasa rao "Microstructure and corrosion behaviour of gas tungsten arc welds of maraging steel" 2014.

12) P. Paulraj, R. Garg "Effect of welding parameters on pitting behavior of GTAWof DSS and super DSS weldments" 2016.

13) Jaiteerth R. Joshi, Mastanaiah Potta, Kumar Adepu, Ramesh Kumar Katta, Madhusudhan Reddy Gankidi "A comparative evaluation of microstructural and mechanical behavior of fiber laser beam and tungsten inert gas dissimilar ultra-high strength steel welds" 2016.

14) Sanket C. Bodkhe, Dhananjay R. Dolas "Optimization of Activated Tungsten Inert Gas Welding of 304L Austenitic Stainless Steel" 2016.

15) https://wiki/Gas_tungsten_arc_welding.