

# **DISSIMILAR METAL JOINING OF STAINLESS STEEL AND TI- 6AL- 4V USING COPPER AS INTERFACED METAL**

Submitted in partial fulfillment of the requirements for the award of  
Bachelor of Engineering degree in Mechanical Engineering

By

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**SCHOOL OF MECHANICAL ENGINEERING**

**SATHYABAMA**

**INSTITUTE OF SCIENCE AND TECHNOLOGY**

**(DEEMED TO BE UNIVERSITY)**

**Accredited with Grade "A" by NAAC 112B Status by UGC I Approved by AICTE**

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**DEPARTMENT OF MECHANICAL ENGINEERING**  
**BONAFIDE CERTIFICATE**

This is to certify that this Project Report is the bonafide work of IYYANARAPPAN J (37150079) and MAHENDRAN M (37150110) who carried out the project entitled “DISSIMILAR METAL JOINING OF STAINLESS STEEL AND TI-6AL-4V USING COPPER AS INTERFACED METAL” under my supervision from August 2020 to April 2021.

**Internal Guide**

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**Submitted for Viva voce Examination held on\_\_\_\_\_**

**Internal Examiner**

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## **DECLARATION**

We, **IYYANARAPPAN J (37150079)** and **MAHENDRAN.M (37150110)**, hereby declare that the Project Report entitled “**DISSIMILAR METAL JOINING OF STAINLESS STEEL AND TI-6AL-4V USING COPPER AS INTERFACED METAL**” done by us under the guidance of **Dr.T.N.VALARMATHI** is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Mechanical Engineering.

**DATE:**

**PLACE: CHENNAI**

**SIGNATURE OF THE CANDIDATE**

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I am pleased to acknowledge my sincere thanks to Board of Management of **SATHYABAMA** for their kind encouragement in doing this project and for completing it successfully. I am grateful to them.

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## **ABSTRACT**

In this project work the dissimilar metal joining of stainless steel (SS304) and Ti- 6AL-4V using copper as interfaced metal was performed using Gas Metal Arc Welding (GMAW) process to analyze the mechanical properties such as hardness and impact strength. During Tungsten Inert Gas (TIG) welding, bevel angle and voltage are varied with a constant current. Titanium's mechanical and chemical properties make it a perfect metal for control plant condenser channels and atomic squander capacity. Titanium permits control plant condenser channels to be solid, lightweight, erosion safe, and slenderer (which permits for superior warm exchange). This all includes up to channels that less demanding to preserve, more effective, and final longer than channels made from other metals. Other metals and materials regularly final 20 a long time, whereas titanium channels have an average life expectancy closer to 40 a long time. Of course, there are too a few potential impediments to titanium, one of which is the trouble of casting. It's too worth specifying that titanium is by and large costlier than other sorts of metals. To Avoid This, in this work welding is performed using both Titanium and Stainless Steel (100X100X2) mm by using copper as interfaced metal to reduce cost and improve welding quality.

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## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 INTRODUCTION TO WELDING**

Metal inert gas/ metal active gas (TIG/MAG) welding is an arc welding process, the melting takes place by Joule effect and a continuous electric arc, where the additional metal is supplied by a roll of wire. The weld is made by falling progressive drops on the weld puddle. Argon gas (TIG welding) or dynamic gas, CO<sub>2</sub> (MAG welding) are utilized as plasma for giving defensive air for the weld metal. The current from the generator is controlled to reach a point chosen by the welder. In the short-circuit mode, where current streams at pre-defined law, in gas metal circular segment welding the liquid metal drop separation shape at terminal have complex intuitive between diverse physical marvels. A few of the analysts have examined the electromagnetic impacts and a few considered the warm impacts and the fluid dynamics. It is an arc welding process where heat is generated for arc between the work piece and a consumable electrode. A bare solid wire called electrode is continuously encouraged to the weld zone, it gets to be filler metal because it is devoured. Gas metal-arc welding overcomes the limitations of utilizing cathode of restricted length and overcomes the failure to weld in various positions, which may be a confinement of submerged-arc welding.

In gas metal circular segment welding, the varieties of power supplies, protecting gasses and terminals have noteworthy impacts, coming about completely different process varieties. But performance of the welding depends to a great extent upon the parameters like voltage, current additionally on sort of work-piece materials, cathode material combinations. In our present study work piece of mild steel material of grade High Carbon High Chromium steel has been used tolerances.

#### **1.2 TYPES OF WELDING**

1. Solid welding
- Friction welding

- Forge welding
- 2. Fusion welding
  - GTAW
  - GMAW

### **1.3 GAS METAL ARC WELDING PROCESS**

Gas metal arc welding (GMAW) is the foremost broadly utilized combination welding process in businesses. It has extensive application, especially, within the car industry. For vehicle chassis, stack and suspension applications, GMAW gives high joint productivity in volume generation and light weight plans by welding thin plates of high quality steels with different thicknesses to create complex assemblies. GMAW is important in many industrial operations. It is effectively found in any industry whose items require metal joining in an expansive scale. It sets up an electric arc between a nonconsumable filler metal electrode and weld pool, with protection from an externally provided gas, which may be an inert gas, an active gas or a blend. Liquid metal from the cathode is exchanged through the arc to the work where it gets to be the deposited weld metal.

### **1.4 IMPORTANT ISSUES IN ARC WELDING**

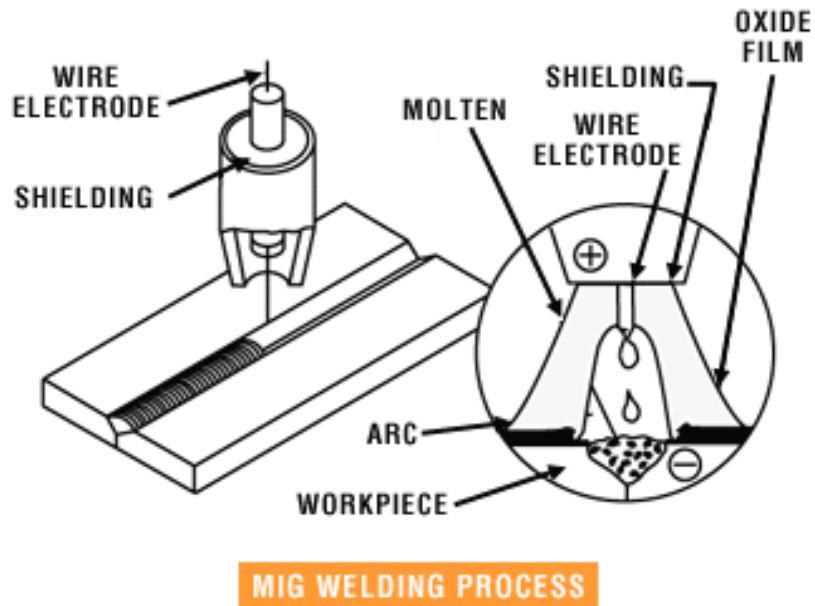
In spite of the fact that arc welding is the most preferred joining process in all manufacturing sectors, it is not free from serious setbacks like residual stresses and distortions in weldment. Due to the highly localized transitory heat input, impressive welding remaining stresses and mishappenings (welding mutilation, welding shrinkage, welding warpage) happen before and after welding. Since arc-welding process involves highly complex thermal cycles, it gives rise to incompatible strains which result in the evolution of residual stresses and distortion in the weldments. The presence of the residual stresses in weldments seriously affects the welded structures, as it prevents the application of full designed loads to the welded structures during their service. Distortions and residual stresses coming about from welding speak to critical issues within the precise manufacture of huge structures. Welding remaining stresses may cause fragile breaks within the wrapped up structure. High stress leftover push areas are risky in a fatigue loaded setting and may induce buckling behavior. These problems increase as

material thickness is reduced and joint frequency is increased, in order to optimize the stiffness-to-weight ratio of welded structures. The tensile residual stresses which often exist in the welded zone induce the further opening up of cracks. Furthermore, these tensile residual stresses reduce the fatigue strength and corrosion resistance but the compressive residual stress reduces the buckling strength of the welded structures. Whereas, the effect of the residual stresses is the most severe in affecting the integrity of the welded joints, distortion becomes more pronounced in the overall structure, particularly in the case of joining very thin materials.

### **1.5 CHARACTERISTIC OF TIG WELDING**

- Uses a consumable wire electrode during the welding process that is fed from a spool,
- Provides a uniform weld bead,
- Requires less operator skill than TIG welding,
- Allows long welds to be made without starts or stops,
- Needs little cleanup.

The illustration that takes after gives a see at an ordinary TIG welding handle appearing a bend that's shaped between the wire terminal and the work piece. Amid the TIG welding handle, the terminal dissolves inside the circular segment and gets to be kept as filler material. The shielding gas that's utilized prevents atmospheric defilement from barometrical defilement and secures the weld amid cementing. The protecting gas moreover helps with stabilizing the circular segment which gives a smooth exchange of metal from the weld wire to the molten weld pool.

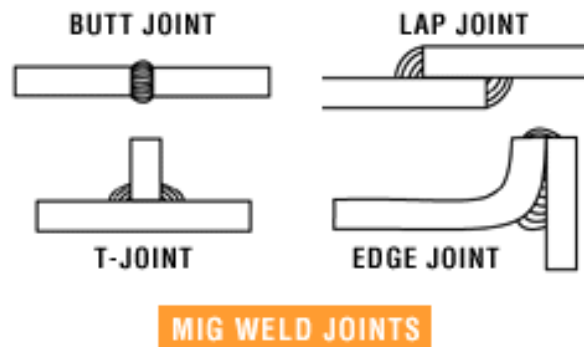


***Fig.1.1: TIG welding process***

Versatility is the major benefit of the TIG welding process.

The most common welds are illustrated below. They include the:

- lap joint
- butt joint
- T-joint, and the
- edge joint



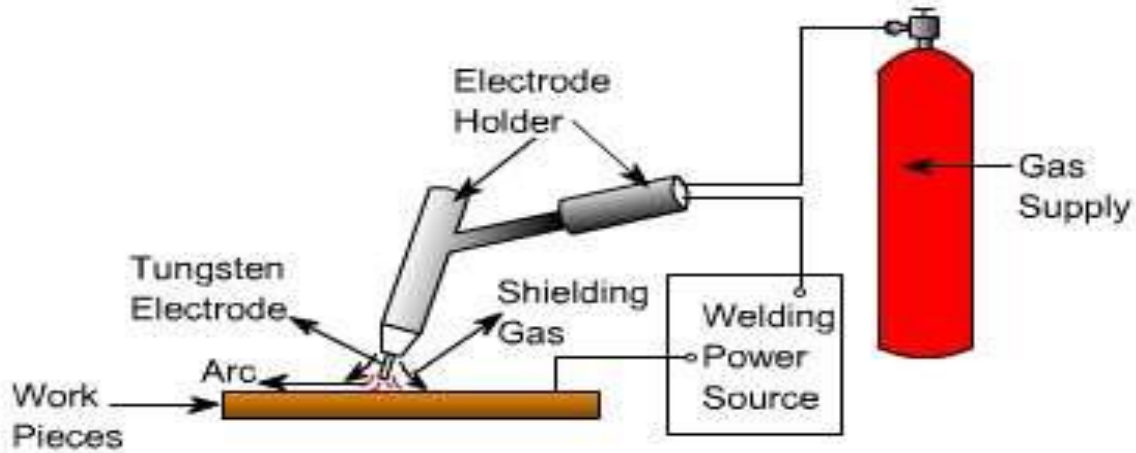
***Fig.1.2: TIG weld joints***

Helium is utilized to weld mellow steel & titanium in tall speed prepare additionally copper and stainless steel.

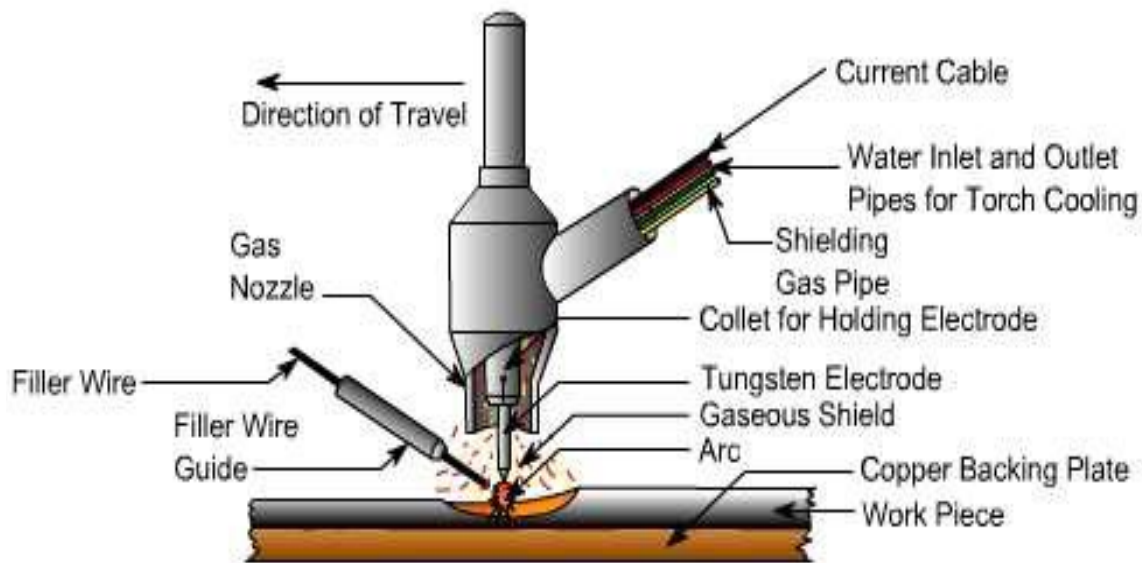
### **1.5.1 Applications**

The TIG/MAG handle demonstrated itself profoundly valuable for rationalized welding of unalloyed and low-alloy auxiliary steels, nowadays it can be best put to utilize for aluminum amalgams, high quality auxiliary steels, and stainless steel. Usually due to the beat and plunges exchange circular segments techniques. Despite of the sort of circular segment, TIG/MAG shows critical points of interest over other welding forms. These include good testimony rate, more profound combination entrance, basic taking care of and add up to mechanization, in expansion to tall efficiency. With the entry of modified welding, gas-metal arc welding has ended up the transcendent process choice. The process of TIG/MAG is getting wider applications in the areas of high-production and automated applications i.e. transport building industry, pipelines, tack welding, weight vessels, gas barrels welding and upkeep repairs.

An electric arc is then created between the tungsten electrode and the work piece using a constant-current welding control supply that produces vitality and conducted over the bend through a column of exceedingly ionized gas and metal vapors. The tungsten terminal and the welding zone are secured from the encompassing discuss by inactive gas. The electric bend can create temperatures of up to 20,000oC and this warm can be centered to soften and connect two distinctive portion of fabric. The weld pool can be utilized to connect the base metal with or without filler fabric. Schematic chart of TIG welding and component of TIG welding are appeared in Fig. 1.3 and Fig. 1.4 respectively.



**Fig 1.3: Schematic Diagram of TIG Welding System.**



**Fig. 1.4: Principle of TIG Welding**

Tungsten electrodes are commonly available from 0.50 mm to 6.40 mm diameter and 150 - 200mm length. The current carrying capacity of each measure of cathode depends on whether it is associated to negative or positive terminal of DC control source. The control source required to preserve the TIG circular segment includes a hanging or consistent current characteristic which gives an basically consistent current yield when the bend length is changed over a few millimeters.

## **1.6 TYPES OF WELDING CURRENT USED IN TIG WELDING**

### **1.6.1 DCSP (Direct Current Straight Polarity)**

In this type of TIG welding direct current is used. Tungsten cathode is associated to the negative terminal of the control supply. This sort of association is the foremost commonly utilized DC welding prepare. With the tungsten being associated to the negative terminal it'll as it were get 30% of the welding vitality (warm).

### **1.6.2 DCRP (Direct Current Reverse Polarity)**

In this type of TIG welding setting tungsten anode is associated to the positive terminal of control supply. This sort of association is utilized exceptionally once in a while since most warm is on the tungsten, in this way the tungsten can effortlessly overheat and burn away. DCRP produces a shallow, wide profile and is mainly used on light material at low Amp.

### **1.6.3 AC (Alternating Current)**

The heat input to the tungsten is found the middle value of out as the AC wave passes from one side of the wave to the other. This will result in the lifting of any oxide skin on the base material.

### **1.6.4 Alternating current with square wave**

With the coming of advanced power AC welding machines can presently be delivered with a wave form called Square Wave. The square wave has superior control and each side of the wave can donate a more cleaning half of the welding cycle and more penetration.

### **1.6.5 Advantages of TIG welding**

TIG welding prepare has particular points of interest over other bend welding handle as follows:

- Contract concentrated arc

- Able to weld ferrous and non-ferrous metals
- Does not utilize flux or take off any slag (protecting gas is utilized to ensure the weld-pool and tungsten electrode)
- No scatter and vapor amid TIG welding

## **1.7 APPLICATIONS OF TIG WELDING**

The TIG welding handle is best suited for metal plate of thickness around 5- 6 mm. TIG welding can be performed in all positions and the method is valuable for tube and pipe joint.

The TIG welding may be a profoundly controllable and clean prepare needs exceptionally small wrapping up. The TIG welding prepare is broadly utilized within the so-called high-tech industry applications such as

- I. Nuclear industry
- II. Aircraft
- III. Food processing industry
- IV. Precision manufacturing industry
- V. Automobile industry

## **1.8 PROCESS PARAMETERS OF TIG WELDING**

The parameters which influence the quality and result of the TIG welding prepare are given below. Welding Current Higher current in TIG welding can lead to splatter and work piece gotten to be damage. Again lower current setting in TIG welding lead to staying of the filler wire. Sometimes larger warm influenced region can be found for lower welding current, as tall temperatures require to applied for longer periods of time to store the same sum of filling materials. Fixed current mode will change the voltage in arrange to preserve a steady circular segment current. Welding Voltage

Welding Voltage can be settled or flexible depending on the TIG welding equipment. A tall starting voltage permits for simple circular segment start and a more noteworthy extend of working tip separate. As well tall voltage, can lead to expansive variable in welding quality.

### **1.8.1 Inert Gases**

The choice of protecting gas is depending on the working metals and impacts on the welding fetched, weld temperature, bend soundness, weld speed, splatter, terminal life etc. it also affects the wrapped up weld entrance significance and surface profile, porosity, disintegration resistance, strength, hardness and brittleness of the weld fabric. Argon or Helium may be used successfully for TIG welding applications. For welding of extremely thin material pure argon is used. Argon generally provides an arc which operates more smoothly and quietly. Penetration of arc is less when Argon is utilized than the bend gotten by the utilize of Helium. For these reasons argon is favored for most of the applications, but where higher warm and penetration is required for welding metals of tall warm conductivity in bigger thicknesses. Aluminum and copper are metals of tall warm conductivity and are illustrations of the sort of material for which helium is profitable in welding moderately thick areas. Unadulterated argon can be utilized for welding of basic steels, moo alloyed steels, stainless steels, Aluminum, copper, titanium and magnesium. Argon hydrogen blend is utilized for welding of some grades of stainless steels and nickel amalgams. Unadulterated helium may be utilized for Aluminum and copper. Helium argon blends may be utilized for moo amalgam steels, Aluminum and copper.

## **CHAPTER 2**

## 2.1 LITREATURE SURVEY

**Harikrishna Rana, et al [1]** investigated the influences of single component fluxes on the depth-to-width ratio (DWR) of oxygen free copper was carried out with novel variants of tungsten inert gas (TIG) welding.

**Jipeng Sh, et al [2]** investigated the influence of shielding gas compositions with different CO<sub>2</sub> contents on the weld appearance and performance were studied in laser-tungsten inert gas (TIG) hybrid welding process.

**Kumar, et al [3]** reported research work in this area is scanty. A comparative study was performed to understand the friction welding characteristics of Tie6Al<sub>4</sub>V and SS304L with copper as interlayer and without interlayer.

**Yan Zhang, et al [4]** Laser welding-brazing of TC4 Titanium (Ti) alloy to 304 stainless steel (SS) has been applied using 38Zn-61Cu alloy as filler metal. The area enclosed by the temperature field contours in the brazed weld was less than that enclosed by the temperature field pro-files in the fusion weld.

**Yan Zhang, et al [5]** laser welding of TC4 Titanium (Ti) alloy and SUS301 L stainless steel (SS) dissimilar metal material was carried out without filler metal by laser biasing. Due to the presence of unmelted Ti alloys, the formation of Ti-Fe intermetallic compounds was not found in the weld zone, but only in the narrow region of the reaction layer at the Ti-SS interface, which improved the mechanical properties of the joints.

**Yan Zhang, et al [6]** Cu was used as an interlayer to prevent the formation of these brittle Ti-Fe intermetallics when joining Ti alloy to stainless steel (SS). Microstructures of the joint were analyzed. The tensile strengths of the joint were also measured.

**Yuan Bo B, et al [7]** Laser welding was performed to join 304 stainless steel (SS) and TC4 Titanium (Ti) alloy using Monel 400/Nb bilayer. In order to avoid the formation of Ti-based and NbFe inter metallics, two pass welding involves creating two fusion weld separated by unmelted Monel 400 and Nb interlayer. A joint with a maximum tensile strength of 258 MPa was obtained.

**Zhi Cheng, et al [8]** brazing of microstructures and mechanical properties of the joint were investigated. The butt brazing of Ti6Al<sub>4</sub>V and 304ss plates with sound double-sided weld appearance was achieved by MIG-TIG double-sided arc welding with copper filler metal.

## **CHAPTER 3**

### **WELDING PROBLEM ON HIGH CARBON STEEL**

#### **3.1 SCOPE OF THE PROJECT**

The main objective of the project is during welding process we have to get the minimum changes in the physical properties and no metallurgical defect is present. Defect free welding process should be made. To achieve a good weldment we will be working with many samples and quality checks with destructive and nondestructive testing in this experimental work.

#### **3.2 PROBLEM IDENTIFICATION**

In numerous cases the welder needs as it were to know the methods of genuine welding and does not ought to be concerned about the type or review of steel being welded. This is often since a expansive sum of steel utilized in creating a metal structure is moo Carbon or plain carbon steel (too called mild steel).

Steels that have higher sums of Carbon or the other amalgams included may require extraordinary methods such as preheating and moderate cooling, to avoid breaking or changing the quality characteristics of the steel. The welder may be included in taking after a particular welding strategy to guarantee weld metal and base metal have the specified quality characteristics.

#### **3.3 THE EFFECT OF WELDING ON HGH CARBON STEEL**

Steel is an alloy, or metallic mixture, containing primarily iron. A variety of other metals, such as carbon, are used to promote certain properties in the alloy. Carbon includes a reinforcing impact when included to press. There are different types of steel available, including several varieties of carbon steel. Low-carbon steel contains a greatest concentration of 0.3 percent carbon, whereas high-carbon steel contains a greatest concentration of 1 percent carbon.

Carbon strengthens steel, but also reduces its ductility, or pliability. The low ductility of high-carbon steel makes it more troublesome to weld. When welding high-

carbon steel, a high concentration of martensite may form in the weld. Martensite makes the metal amazingly fragile, causing a powerless weld that will break as before long because it cools. According to ESAB Welding and Cutting, Inc., a low hydrogen electrode must be used when welding high-carbon steels. Furthermore, tempering, or warming, the metal earlier to welding moderates the cooling handle and avoids the concentration of martensite. Post warming will too decrease push and fortify the weld.

### **3.4 WELDING DEFECTS**

Within the rectify sense of the word, an imperfection could be a rejectable brokenness or a imperfection of rejectable nature. Certain flaws palatable in one sort of thing. An imperfection is unquestionably an irregularity, but a brokenness requires not fundamentally be a deformity. Acknowledgment or dismissal of imperfections is based on distinctive components and to specify a crucial few are:

- Stress to which the parts will be subjected during service.
- Types of material used.
- Temperature and pressure to which the parts will be stressed.
- Thickness.
- The environment (corrosive or non-corrosive).
- Safety.
- Consequence of failure.
- Cost and easy to repair, etc

Acceptance standards dictate the type of inspection and testing the weld is subjected to before giving a judgement. It is of immense importance to see that the base material used for fabrication shall be of good quality and attested materials are demanded in the fabricate of space vehicles and ships, submarines, weight vessels, control evaporator components, overwhelming obligation cranes, structures, bridges, etc, wherein the disappointment of weld will lead to misfortune of life, cash and notoriety.

The weld surrenders can be broadly classified into two sorts. They are:

- Planar defects/ two dimensional defects.
- Voluminar defects / three dimensional defects.

Planar abandons such as split, need of combination, need of infiltration, extreme undermined are basic in nature and include need of holding and are not endured to any extent.

Voluminar surrenders such as slag incorporation, cavities, pores, etc. are endured to a certain degree depending on the item lesson. Geometric imperfection such as overabundance fortification, under fill or under flush, root concavity is too allowed to a certain degree. On the off chance that they from sharp indents, they are smoothened out wherever open to maintain a strategic distance from stretch concentration.

### **3.5 GENERAL REASON FOR DEFECTS**

The importance of weld quality is increasingly felt as we go ahead with the fabrication of sophisticated products using higher strength materials combined with critical design consideration. Defects are generally introduced because of:

- Lack of knowhow and experience.
- Welding process characteristics.
- Base metal composition.
- Defective welding filler metals.
- Joint design.
- Welding environment (wind, fit up, temperature, etc.)

### **3.6 TYPE OF DEFECTS AND THEIR SIGNIFICANCE**

Defects in weldments in common can be classified as follows:

#### **1. Defects including insufficient bonding**

- Incomplete penetration
- Lack of combination

#### **2. Foreign Inclusions**

- Slag
- Oxide films

#### **3. Geometric Defects**

- Distortion
- Undercut
- Burn through or intemperate penetration

- Excessive reinforcement
- Improper weld profile

#### **4. Metallurgical defects**

- Gas porosity
- Cracks
- Arc strikes
- Structural scores
- Embrittlement

### **3.7 METALLURGICAL DEFECTS**

#### **CRACKS:**

Cracks are the linear ruptures of the metal under stress.

- Cold cracking
- Hot cracking
- Base metal cracking
- Microfissuring
- Crater cracking.

#### **Reason for cracking:**

1. Base metal composition
2. Welding prepare characteristics
3. Imperfect welding filler materials
4. Welding environment
5. Joint design
6. Breaking may happen in:
  - i) Heat influenced zone
  - ii) Weld metal

#### **Hot cracking:**

Hot cracking occurs at elevated temperature during cooling and solidifying from the molten stage. The most causes are the restriction on the joint and the nearness of higher carbon and sulfur. The other reason is segregation of weld metal due to bead

shape. Hot cracks are inter-granular. To avoid hot cracks, it is essential to keep these joints with least restraint and to have least amount of heat input.

**Cold cracking:**

Cold splitting in steels alludes to breaking which happens indeed after a number of days. In general, cold cracking starts in the Heat Affected Zone (HAZ) of the weld metal. It is primarily associated with combined effects of hydrogen, restraint and martensite formation..

**CHAPTER 4**

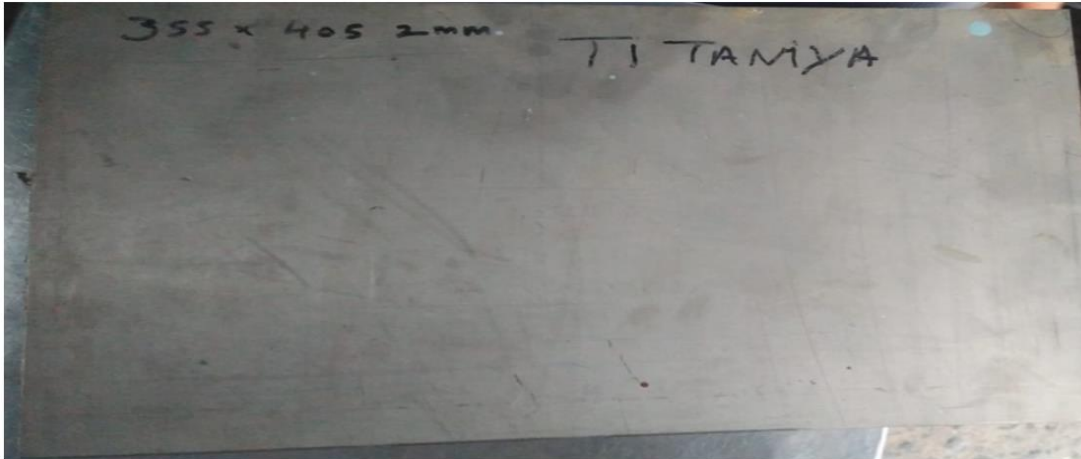
## MATERIALS AND EXPERIMENTAL ANALYSIS

### 4.1 INTRODUCTION

Welding experiments are performed to analyze the mechanical properties of dissimilar welding of TI-6AL-4V and SS304 using TIG welding process.

### 4.2 TI - 6AL - 4V Material

The Titanium material (TI - 6AL - 4V) used for the welding experiment is shown in Fig.4.1.



*Fig. 4.1: TI-6AL-4V Material*

The chemical and physical properties of TI - 6AL - 4V steel is presented in Table 4.1 and 4.2.

**Table 4.1: Chemical properties**

| Element          | Composition in weight % |         |
|------------------|-------------------------|---------|
|                  | Min                     | Max     |
| Poisson's Ratio  | 0.31                    | 0.37    |
| Shear Modulus    | 40                      | 6.5267  |
| Tensile Strength | 862                     | 174.045 |
| Young's Modulus  | 110                     | 17.2595 |

**Table 4.2: Physical properties**

| Size<br>mm | Tensile<br>Strength<br>N/mm <sup>2</sup> | Yield<br>Stress<br>N/mm <sup>2</sup> | Elongation | Impact<br>Izod J | Impact<br>KCV J | Hardness<br>HB |
|------------|------------------------------------------|--------------------------------------|------------|------------------|-----------------|----------------|
| 63 to 150  | 850-1000                                 | 680 Min                              | 13%        | 54               | 50              | 248/302        |

### 4.3 APPLICATIONS

TI-6AL-4V steel is a high tensile alloy steel and wear resistance properties and also where high strength properties are required. TI-6AL-4V is used in components subject to high stress and with a large cross section. This could incorporate airplane, car and common building applications for case propeller or equip shafts, interfacing poles, airplane landing adapt components.

### 4.4 SS304 Material

|                  |               |
|------------------|---------------|
| Composition Type | 304           |
| Carbon           | 0.030max      |
| Chromium         | 18.00 – 20.00 |
| Nickel           | 8.00 – 12.00  |
| Manganese        | 2.00max       |
| Silicon          | 1.00max       |
| Phosphorus       | 0.045max      |
| Sulfur           | 0.030max      |



**Fig. 4.2: SS304 Material**

**Table 4.3: Typical tensile properties of SS304**

| Form  | Tensile Strength<br>Psi | Yield<br>Strength<br>(0.2% offset) Psi | Elongation<br>(2.in) % | Rock well<br>Hardness |
|-------|-------------------------|----------------------------------------|------------------------|-----------------------|
| Plate | 79000<br>81000          | 33000<br>39000                         | 60<br>55               | B 79                  |

**Table 4.4: Test results**

| Test<br>Temperature | Tensile<br>Strength Psi | Yield Strength<br>(0.2% in. offset) | Elongation<br>(2 in) % | Reduction<br>of Area (%) |
|---------------------|-------------------------|-------------------------------------|------------------------|--------------------------|
| Room                | 80000                   | 30000                               | 60                     | 77                       |
| 400                 | 60000                   | 17000                               | 52                     | 75                       |
| 800                 | 57000                   | 14000                               | 48                     | 68                       |
| 1000                | 52000                   | 12000                               | 45                     | 67                       |

**Weldability:**

These steels can be welded by all of the common welding processes that are by covered electrode, inert gas metal arc, inert gas tungsten arc, submerged arc and resistance welding. The newer processes such as the electron beam and laser welding have also been used to advantage. Type 308 filler metal should be used in joining Type 304 and Type 308L for joining Type 304L. The major purpose for using.

**General Characteristics:**

AISI 304 and 304L are lower carbon modifications are Type 302. Type 304 has become the most widely used austenitic chromium-nickel stainless steels. It is nonmagnetic in the annealed condition but becomes slightly-magnetic when cold is worked. This steel has excellent corrosion resistance to a wide variety of environments and good mechanical properties. It cannot be hardened by heat treatment by work hardens quite rapidly, developing high strength while retaining good ductility.

**Application:**

Used extensively in equipment for handling acetic, nitric, and citric acids, food and milk products, in valve trim, screws, bolts, for chemical and refinery equipment, hospital equipment, architectural molding and trim, kitchen equipment.

#### 4.5 TIG WELDING MACHINE SPECIFICATION

TIG Welding Machine:

PEAK : 20 -300-AT/TIG

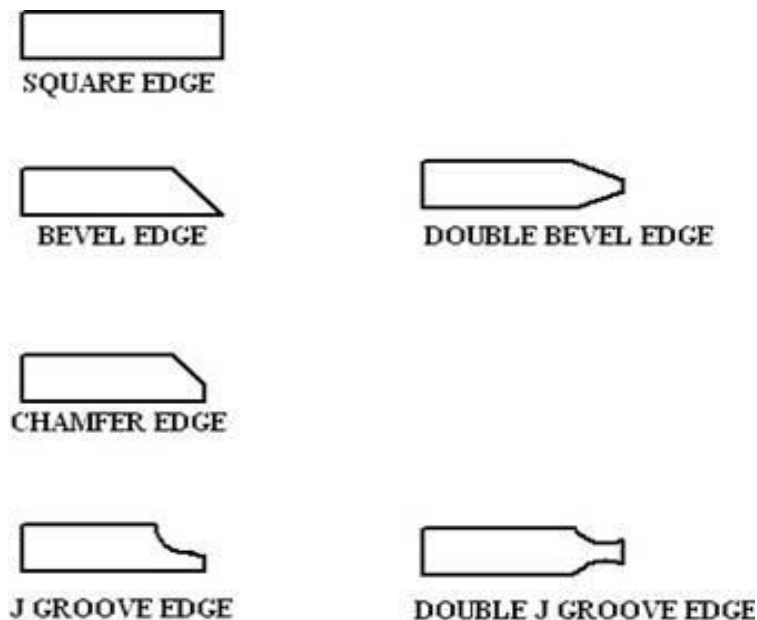
TIG : 16 PEAK /415v

Cooling : Air cooling

Frequency : 50Hz

#### 4.6 EDGE PREPARATION

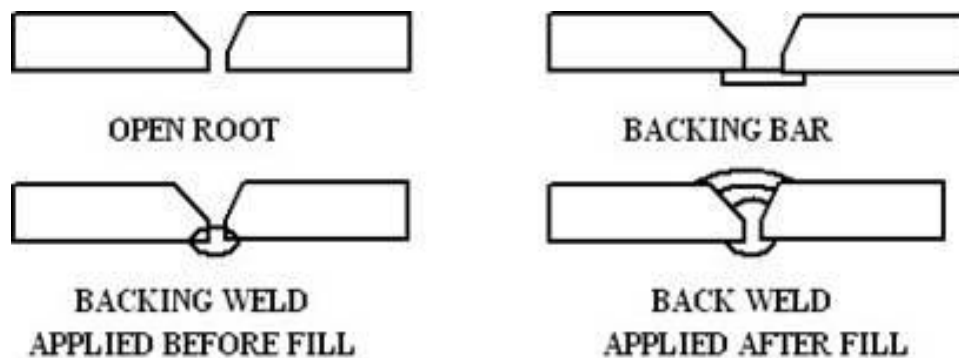
Planning or edge forming may be connected to each piece (joint part) within the same way, or combinations of the joint arrangements may be utilized. The edge arrangement for welding these joints depends on the quality necessities and other design considerations. The Welder must be mindful of the foremost common edge arrangements as appeared underneath:



**Fig.4.2: Edge profile**

## 4.7 JOINT ARRANGEMENTS AND WELDS

The edge arrangements are organized to create the weld joint. The pieces to be welded may be associated or a crevice between the pieces to guarantee entrance may be utilized. On most joints the hole is at the foot of the joint and is alluded to as the root of the joint. The term root opening or open root is utilized to depict this condition. For example; Open root V groove, or V groove with an open root. When the joint plan permits, a backing strip or embed may be utilized for less demanding welding. A few joints may have a backing weld, or back weld connected. A back weld is connected after the groove is filled. A backing weld is connected some time recently the groove is filled.



**Fig. 4.3: Edge joints**

## 4.8 EXPERIMENTAL SETUP

An AC constant current Sun power source (DC Inverter machine TIG/MMA 500) was used in our experiment is shown in Fig. 4.4. The method required clamping joint in installations, setting welding parameters (voltage, welding current, bend travel speed, wire bolster rate, terminal position and introduction of weapon). The setting of welding parameters is very important so that the right relationship must be gotten between current, voltages, stick-out, gas stream, welding speed and weapon points. There ought to be proper determination of filler wires, and protecting gasses. The method does not require exceptionally talented welders; the welders can be semiskilled welders. Amid the welding uncommon consideration ought to be given to the circular segment glare, smokes, vapor, terminal changing, and spout clean. After the welding has been done, the qualitys of weld globule appearance must be inspected.



*Fig. 4.4: Sun power welding machine*

#### 4.9 TIG WELDING MACHINE SPECIFICATION

**Table 4.5 Welding Machine Specification**

| Parameters                 | Specifications         |
|----------------------------|------------------------|
| Model                      | TIG/MMA500             |
| In put power voltage       | (Single Phase) AC 415V |
| Rated Input power capacity | 26 KVA                 |
| Input voltage Frequency    | 50/160 Hz              |
| Output current Range       | 80~500 Amps            |

|                      |           |
|----------------------|-----------|
| Rated output voltage | 16/5/50 V |
| No load voltage      | 60 V      |

## CHAPTER 5

### RESULTS AND DISCUSSION

#### 5.1 INTRODUCTION OF HARDNESS

The definitions of metallurgic extreme quality and hardness are or maybe comparable, it can for the most part be accepted that a solid metal is additionally a difficult metal.

#### 5.2 ROCKWELL HARDNESS TEST

Rockwell Hardness frameworks utilize a coordinate readout machine deciding the hardness number based upon the profundity of infiltration of either a precious stone point or a steel ball. Profound infiltration shown a fabric having a moo Rockwell Hardness

number. In any case, a moor entrance demonstrates a fabric having a tall Rockwell Hardness number. The Rockwell Hardness number is based upon the contrast within the profundity to which a penetrator is driven by a positive light or “minor” stack and a clear overwhelming or “Major” load. The ball penetrators are chucks that are made to hold 1/16” or 1/8” separate over set steel balls. Moreover accessible are ¼” and ½” ball penetrators for the testing of gentler materials. There are two sorts of press squares that are utilized on the Rockwell hardness analyzers. The level faceplate models are utilized for level illustrations. The “V” sort press squares hold circular cases immovably.<sup>5</sup> Test pieces or calibration pieces are level steel or brass squares, which have been tried and checked with the scale.

Using the “B” Scale;

- a. Use a 1/16 indenter
- b. Major load: 100 Kg, Minor load: 10 Kg
- c. Use for Case hardened steel titanium, tool steel.
- d. Do not use on hardened steel

**Table 5.1: Hardness values**

| <b>SAMPLES</b> | <b>S1</b> | <b>S2</b> | <b>S3</b> |
|----------------|-----------|-----------|-----------|
| TI-6AL-4V      | 88        | 86        | 92        |
| SS304          | 92        | 87        | 84        |

### **5.3 IMPACT TEST**

Izod affect quality testing is an ASTM standard strategy of deciding affect quality. An indented test is by and large utilized to decide affect quality. Affect could be a exceptionally vital wonder in governing the life of a structure. Within the case of flying machine, affect can take put by the fowl hitting the plane while it is cruising, amid take -

off and landing there's affect by the flotsam and jetsam display on the runway. An arm held at a particular stature (steady potential vitality) is discharged. The arm hits the test and breaks it. From the vitality retained by the test, its affect quality is determined. The North American standard for Izod Affect testing is ASTM D256. The comes about are communicated in vitality misplaced per unit of thickness (such as ft-lb/in or J/cm) at the indent. Then again, the comes about may be detailed as vitality misplaced per unit cross-sectional region at the score ( $\text{J/m}^2$  or  $\text{ft-lb/in}^2$ ). In Europe, ISO 180 strategies are utilized and comes about are based as it were on the cross-sectional range at the indent ( $\text{J/m}^2$ ).

The measurements of a standard example for ASTM D256 are 4 x 12.7 x 3.2 mm (2.5" x 0.5" x 1/8"). The foremost common example thickness is 3.2 mm (0.125"), but the width can shift between 3.0 and 12.7 mm (0.118" and 0.500").

The Charpy impact test differs from the Izod impact testin that the sample is held in cantilevered beam as opposed to a three-point bending configuration.

## 5.4 IMPACT STRENGTH

Specification of the machine and Size of the specimen:

|                          |                   |
|--------------------------|-------------------|
| Energy Range             | = 0 – 300 J       |
| Least Count (1 Division) | =1 J              |
| Specimen size            | = 10 X 10 X 55 mm |
| Notch                    | = V NOTCH         |
| Notch Depth              | = 2mm             |

**Table 5.1: Impact strength**

| Materials         | Test Plate | Average Impact strength<br>Joules |
|-------------------|------------|-----------------------------------|
| SS304 & TI-6AL-4V | S1         | 20                                |
|                   | S2         | 20                                |
|                   | S3         | 37                                |

From the results it is observed that the specimen S3 has better impact strength than the other two specimens.

### 5.5 HEAT AFFECTED ZONE - SS304 -TI- 6AL- 4V

The heat affected area of SS304 -TI- 6AL- 4V weld joints in GMAW at various sizes of bead width and depth of penetration is in the following figures:



***Fig. 5.1: View of test plate-1 (AMPS-140, VOLT-18, BEVEL-55)***



**Fig. 5.2: View of test plate-2 (AMPS-140, VOLT-20, BEVEL-65)**



**Fig. 5.3: View of test plate-3 (AMPS-140, VOLT-22, BEVEL-70)**

**Table 5.3: Bead width and depth of penetration**

| SAMPLES | Area  | Mean    | Min    | Max     | Angle | Length |
|---------|-------|---------|--------|---------|-------|--------|
| S1      | 0.427 | 150.246 | 35.667 | 216     | 180   | 14.234 |
|         | 0.203 | 101.344 | 25.333 | 252.667 | 90    | 6.757  |
| S2      | 0.384 | 101.224 | 76.333 | 238.333 | 180   | 12.793 |

|    |       |         |        |         |     |        |
|----|-------|---------|--------|---------|-----|--------|
|    | 0.179 | 130.397 | 34     | 196     | 90  | 5.946  |
| S3 | 0.419 | 125.962 | 52.667 | 187.667 | 180 | 13.964 |
|    | 0.179 | 123.285 | 34     | 179.667 | 90  | 5.946  |

From the results it is observed that the specimen S3 has better welding quality than the other two specimens.

## CHAPTER 6

### SUMMARY AND CONCLUSION

#### 6.1 CONCLUSION

TIG welding can be used successfully to join SS304&TI-6AL-4V. The handled joints shown superior mechanical and metallurgical characteristics. In our experiment we found out the input parameter value 140 AMPS, VOLT-22 and BEVEL ANGLE -70 ° is the best value and it does not create any major changes and failures in the testing process. The toughness value of the TIG welded dissimilar steel was comparatively higher value (140 AMPS, VOLT-22, BEVEL ANGLE-70°) than other value. It also induces high tensile strength. Finally, it is concluded that in this project investigation the 140 AMPS, VOLT-22 with BEVEL-70° combination in dissimilar welding of 10 mm thickness plate gives good weldment.

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