# INVESTIGATION OF DISSIMILAR V-JOINT OF STEEL ALLOYS WITH COPPER AND BRASS USING TIG WELDING

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**Abstract** - The aim of this research was to explore the new domain of dissimilar welding owing to its increasing industrial applications. Using tungsten inert gas(TIG) welding technique, the four different materials Copper c15000,Brass c260, Mild Steel and Stainless steel were bevel-joinedeach with a sample of Stainless Steel as a base material, under controlled welding parameters. The experiments were performed using ER70S-6 Filler rod. The tensile strength of the specimens wasanalyzed, and stress-strain curve was obtained using Universal Testing machine(UTS). All the specimens depicted good weld strength with SS304-Mild Steel showing better quality. The highest tensile strength obtained was 42KN for Stainless Steel(SS304)-Mild Steel specimen compared to BC260-Mild Steel(28KN) and C15000-Mild Steel(25KN) specimens. It was concluded that the SS304-Mild steel sample showed optimal mechanical strength. These results are restricted under specified welding parameters and can be further optimized by varying different welding parameters.

**Keywords** - Dissimilar Welding, TIG welding, V-Joint Weld, Steel Alloys, Copper Alloys, Brass Alloys, Radiography, Mechanical Testing

## I. INTRODUCTION

In the present Era welding is the most common and durable option to join the materials permanently. It is applicable in almost all the industries i.e. from aerospace fabrication to the automotive generations. Because of its versatility and the strength, welding process is applied in almost all the manufacturing processes for making the products that are used in daily life. The variety in the shapes of products can be brought by using welding techniques. The most common technique of welding that is under use is tungsten inert gas (TIG) welding. Now a day a new trend Dissimilar Welding that is the welding between the metals with different grades and types is becoming so popular in industrial market to meet the raising demand and requirements. It is very complicated and challenging process because every material has different properties with respect to others. A lot of research has done on the Dissimilar welding. The new material that is under consideration for the dissimiliar welding is steel and this process is all about disimiliar welding of steel.The unique quality of the Stainless Steel is that it not only makes the welding fusion with other materials but also it makes with its own alloys and that are more durable and long lasting. It shows variety of mechanical properties when welded with other materials according to the requirement and desired conditions. Steel can be easily welded with Copper, Brass, Aluminiumetc and its own alloys too. When welded with Aluminium the final specimen can have tensile strength from 130 to 220 MPa, the variation depends upon the welding parameters, and its yield strength is upto 176 Mpa. Similarly the researches shows that when Steel is welded with its own alloys i.e Mild Steel its strength increases up to 160 MPa. Steel Copper welding also yields ultimate tensile strength up to 166 MPa. There is a great strength that is achieved by having welding of Steel and Brass, its hardness is also very attractive.

## II. LITERATURE REVIEW

Liming, Liu Xujing&Shunhua Liu [1] investigated the microstructure of laser welding formed between dissimilar metals i.eMg alloy and Al alloy with Ce as interlayer and founded elimination of the formed intermetallic phases between aluminum and magnesium alloy. Peng Liu [2] studied microstructure characteristics of welded joint of Mg/Al and deduced the results that micro-hardness near fusion zone of Mg is HM 275-300, and of Al is HM 160-200, and of weld metal is HM 60-100. San-bao Lin [3] studied welding of aluminum alloy to galvanized and recorded that steel zinc coated layer can improve the wettability and spread ability of liquid aluminum filler metal on the surface of the steel when the wetting angle reach less than 20°. J.L song, S.B Lin, C.L Yang,G.C Ma &H.Liu [4] together investigated spreading behavior and microstructure characteristics of aluminium alloy to stainless steel welding and founded that tensile strength of butt joint reached 120MPA,Cracks occur from top part of brittle Fe2Al5 when its thickness exceed 10 μm. Xiaodong Qi [5] investigated Interfacial structure of magnesium alloy and mild steel welding and founded that the shear strength of the joints could reach around 176 MPa, 110% that of base material of Mg alloy whose shear strength is 160 MPa. J. L. Song [6] analyzed the intermetallic layer of aluminium alloy to stainless steel welding and founded that filler (Al,Si)13Fe4 layer presents high crack resistance with tensile strength of 155–175 MPa. R.Borrisutthekul,

P.Mitsomwang, S. Rattanachan& Y. Mutoh [7] studied feasibility of Steel/Aluminum Alloy and concluded that the load resistance of welded zone of joint as higher than that of A1100 aluminum alloy after welding. Liming Liu &Xiaodong Qi [8] investigated strengthening effect of nickel and copper interlayers between the welding of magnesium alloy and mild steel and founded that 160 MPa is the UTSS of base material AZ31B Mg alloy and UTSS of Cu-added joint which is 170 MPa is a little larger than that of Ni-added one that is 166 MPa. R. Borrisutthekula, P. Mitsomwanga,&S.Rattanachana [9] investigated effects of TIG Welding Parameters on welding between Mild Steel and 5052 Aluminum Alloy and founded that at constant heat by increasing arc length increases weld width of lap joint. ZhiZenga, that the welding was feasible, haveBetter Strength and high hardness. Prashant Kumar Singh, Pankaj Kumar& Rahul Kumar [15] reviewed TIG Welding for optimizing process of SS-304 and MS-1018 and concluded that welding conditions can affected the weld strength and microstructure. L.H. Shah [16] did research on welding of Aluminium 6061 and Galvanized Iron and knew that GI-Al configuration with filler ER4043 can give better mechanical properties. Van Nhat& Nguyen [17] investigated welding of Aluminum Alloys to Stainless Steel and found fracture on the area adjacent between welding seam and A6061 alloys plate which was due to highly applied current. PoojaAngolkar,JSaikrishna, Dr.R.Venkat&P.RavikanthRaju [18] investigated welding of SS316 and Monel400 and founded that average hardness was 234 anf tensile strength of 200KN. Pushp Kumar &Baghel [19] studied Mechanical properties and microstructural of welding of aluminum alloy 5083 and 6061 and founded that welded joints shows 213MPa ultimate tensile strength and yield Strength of 176 Mpa with rapture at the surface because of excessive or insufficient heat.
on welding of 5083 Aluminum Alloy to CuZn34 Brass and founded that the maximum tensile shear strength of aluminum and brass through FSW can be achieved at welding speed of 6.5 mm/min and at1120 rpm. Caiwang Tan, Liqun Li, Yanbin Chen & Wei Guo [12] investigated welding of AZ31B Mg alloy to Zn coated Steel and found that welded joints shows 68MPa and 52.3% joint efficiency as compared to Mg base metal. A. R. Khalife, A. Dehghan&E. Hajjari [13] investigated joining of AISI 304L/St37 steels by welding and founded that highest impact energy was 160. Xunbo Li, Yugang Miao, Gang Wu &ZijunZhaoa [10] did numerical and experiment analysis of residual stresses on magnesium and steel butt joints and concluded that the residual stress on the 304L steel plate is lower than that on the AZ31B magnesium plate. MostafaAkbari [11] did research J when welded by ER310 electrode and the lowest impact energy was 120 J when ER309L electrode was used. J.Pasupathy&V.Ravisankar [14] did detailed Study on welding of Low Carbon Steel with AA1050 and concluded

## III. EXPERIMENTAL METHODOLOGY

### 3.1 Materials:

Three welded samples of dissimilar metals were prepared. The basic materials used were non-ferrous metals such as Copper and Brass and ferrous metals such as mild Steel and Stainless steel plates. According to ASME SECTION IX, the dimensions and the geometry of initial raw materials are given in table1:

| Raw Materials | Geometry | Length | Width | Thickness |
|---|---|---|---|---|
| Copper, Brass, Mild Steel and SS | Plate | 240mm | 31.7mm | 3mm |

**Table1: Raw Materials and geometry os specimen**

### 3.2 Raw Materials composition:

The raw materials are used in this research are stainless steel SS304, copper C15000, and brass C260 each with a thickness of 3mm and length of 240mm. Chemical composition of raw materials in tabulated form is:

| | C | Mn | Si | P | S | Cr | Mo |
|---|---|---|---|---|---|---|---|
| Steel 304 | 0.07 | 2 | 0.075 | 0.045 | 0.030 | 19.5 | - |

**Table2: Composition of Steel 304 in wt%**

| Elements | Zr | Cu | Si | P | S | Cr | Mo |
|---|---|---|---|---|---|---|---|
| Copper C15000 | 0.02 | 99.8 | - | - | - | - | - |

**Table3: Composition of Copper c15000 in wt%**

| Elements | Fe | Cu | Si | Pb | S | Cr | Mo |
|---|---|---|---|---|---|---|---|
| Brass C260 | 0.05 | 71.5 | - | 0.07 | - | - | - |

**Table4: Composition of Brass c260 in wt%**

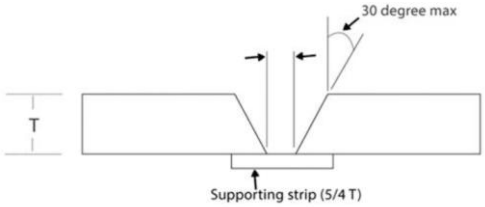
### 3.3 Pre-Weld treatment of Raw Materials:

As the preparation of raw material is necessary to obtain quality weldedjoints. So, the raw plates were made to undergo the pre-weld treatment which included cleaning of metal surfaces, removing rust or any other coatings, removing moisture and lowering yield temperature to ensure that the area to be welded is in the best condition.

### 3.4 Welding Requirements:

**Joint:**

The V butt joint as per ASME SECTION IX is show below:




QW-469.1 Single V BUTT JOINT

**Figure-1**

*ASME SECTION IX TENSILE WELD SAMPLE*

Now as per requirements of sample the work piece is sheared in two rectangular parts each of 120mm length by successive machining later on the sharp edges of rectangular parts are removed by machining process to create bevel joint as shown in below figure2.




**Figure-2**

*Flat surface into beveled surface*

After the cutting action, three different specimens are welded in different manner (stainless steel to copper c15000) using available Argon Tig Welding machine 200amps.

### 3.5 Welding Parameters:

| Current | Voltage | Frequency | Electrode Tip Angle | Welding Speed |
|---|---|---|---|---|
| 125Amps | 18V | 50Hz | 20° | 3.8mm/s |

### 3.6 Filler Rod:

*(3.2mm ER70S-6 Mild Steel Filler Rod)*




**Figure 3** *Tig Welding*

### 3.7 Cutting Weld Samples Dimensions:

The Tensile samples to be analyzed according to ASME section IX is shown below in Figure A. The length of specimen is taken to be 240mm, and a plate thickness of 3mm.

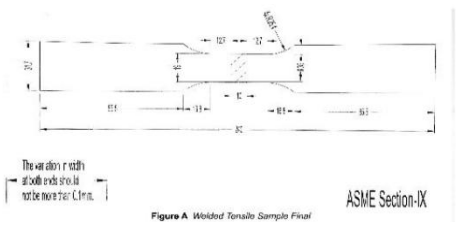



**Figure A** *Welded Tensile Sample Final*

The specimen is divided into two rectangular parts equally, and the welding operation is performed at the center of the specimen. The dimensions of the specimen are taken according to standard to get an optimum result.

## IV. ANALYSIS TECHNIQUES EMPLOYED

### 4.1 Radiography

Radio graphic welding method is one of the most usual non-destructive testing apply to observe gap within in internal shape of welds. The salient advantage of this method is its capability to conduct the weld's internal unification without damaging the welded part. In radiographic testing,X-rays created by X-ray tube or gamma-rays created by a radioactive isotope is utilized.Via jellied entity the perforation radiation proceed onto photographic film, processing the image of entity's internal formation being shove on the film. The amount of energy depends on the solidity and broadness of the entity sponge up by it. Remaining consignment of energy will root vulnerability of the radiographic film. After deployment of film, the area will become dark.

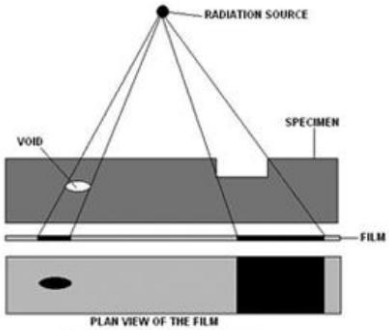



**Figure 4** *Industrial Radiography*

Those area will be lighter which is exposed to less energy. Hatswhy, the area of the entity will emerge as dark outlines film where the thickness has been changed due to discontinuities, such as cracks orporosity. Insertion of low solidity(slag) will appear as dark while insertion of high solidity(tungsten) will appear as light area. All discontinuities are distinguished by review shape and variety in thickness of the handled film. Radiographic testing can produce a perpetual film information of weld standard that is comparatively uncomplicated to elucidate by indoctrinate manpower.

This testing technique is generally suited to having ingress to both sides of the welded joint. While this is a ponderous and costly technique of non-destructive testing, it is a constructive technique for perceiving permeability, incretion, crevice, and gaps in the inner of welds. It is necessary that indoctrinate manpower conduct radiographic elucidation since false elucidation of radiographs can be costly and constrain soberly with productivity. There are evident protection deliberation when conducting radiographic

testing. X-ray and gamma radiation is useable to the human eye and can have dangerous health and safety implications. Only suitably instructed and qualified personnel should perform this kind of testing.

### 4.2 Tensile Testing

Tensile testing is a test in which a specimen is exposed to a supervise tension till failure. Properties that are directly calculated through a tensile test are ultimate tensile strength, breaking, strength, maximum elongation and reduction in area. Tensile testing is conducted as it tells how a specimen will behave under normal and extreme forces or stresses providing data for other engineering and quality assurance purposes. Material strength testing, using the tensile tension test technique apply an ever-increasing load on test specimen up to the point of failure. The data created from tensile testing is utilized to find mechanical properties of specimen and provides the following quantitative measurements:

- **Ultimate Tensile Strength (UTS),** is the maximum tensile stress bear by the specimen, defined as the maximum load divided by the original cross-sectional area of the test specimen.
- **Yield strength** is the stress at which time permanent (plastic) deformation or yielding is observed to begin.
- **Ductility measurements** are typically elongation, defined as the strain at, or after, the point of fracture, and reduction of area after the fracture of the test sample.



**Figure 5** *Universal Testing Machine(UTS)*

The test specimen is gripped between bottom and top chuck universal testing machine which is shown below in Figure 5. During the tension test, the grips are moved apart at a constant rate to tug and extend the specimen. The force on the specimen and its displacement is continuously observed. After the tensile test specimen has broken tensile strength, yield strength and ductility, are calculated by the personnel. The test specimen is place back jointly to quantify the final length, then this measurement is compared to the starting length to get change in length.



**Figure 6** *Tensile Testing on UTS MACHINE*

## V. RESULTS AND DISCUSSION

### 5.1 Specimen Appearance

After destruction of specimen, the specimen appearance shows the stress concentrations and mentions the parts of weld where the defects are present. The figure 7shows the appearance of broken specimen. Stainless steel and brass specimen breaks near the joint from brass side showing that the joint is stronger than the brass. Stainless and mild steel specimen breaks near the joint from stainless steel side showing that the joint is stronger than the stainless steel. The stainless steel and copper specimen breaks at the weld showing that the joint is weak.

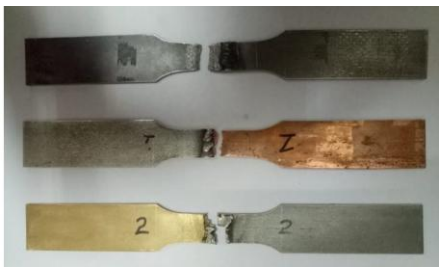
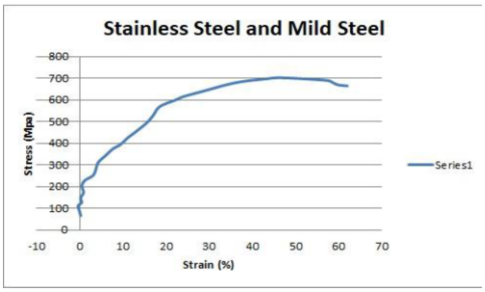


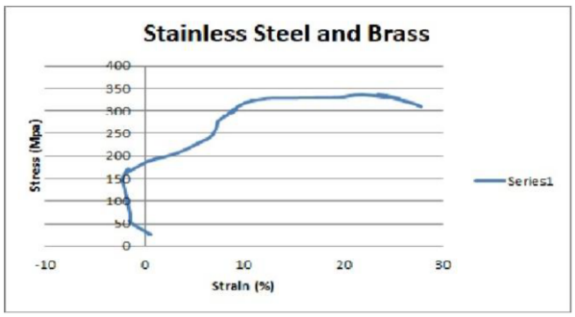
**Figure 7 Broken specimen**

### 5.2 Fracture and Mechanical Properties

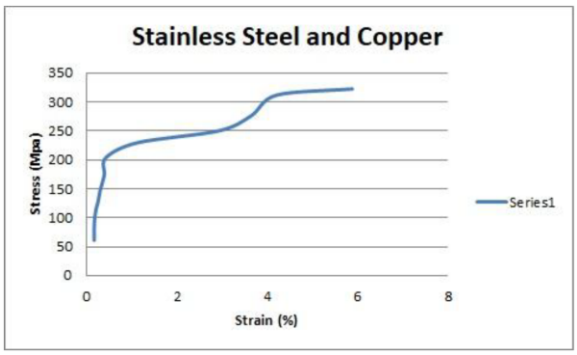
A tensile test was performed on the specimen and the results of test in the form of stress strain curve are shown in Graph 1, Graph 2 and Graph 3.The Graph 1 shows that the ultimate tensile stress (UTS) of stainless steel is 702MPa. The Graph 2 shows that the ultimate tensile stress (UTS) of brass is 338.9MPa.The Graph 3 shows that the ultimate tensile stress (UTS) of stainless steel and copper joint is 322.2MPa. The breaking of stainless steel and copper joint at 322.2MPa shows that the welding is defected.




**Graph 1 Stress strain curve forstainless steel and mild steel joint**




**Graph 2 Stress strain curve forstainless steel and brass joint**




**Graph 1 Stress strain curve forstainless steel and copper joint**

## VI. CONCLUSION

In this paper, an attempt was made to investigate the v-joint TIG dissimilar welding of non-ferrous metals such as brass c260, copper c15000 and ferrous metals such as stainless steel, mild steel plates by using tungsten red as filler material. The tensile test performed on the specimen shows that the weld between mild steel and stainless steel (strength=42kN) is stronger than the weld between brass and stainless steel (strength=28kN) and weld between copper and stainless steel (strength=25kN) is lesser. So, it can be concluded that the dissimilar welding between mild steel and stainless steel is more strong. However, this experiment is restricted to only a few specimens and welding parameters. The joint strength can be further enhanced in the future by additional parameter optimization, including other welding variables, using an automated welding machine, as well as proper customized jig fixtures to ensure a better weld quality finish.

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