Mechanical and Microstuctural Analysis of Dissimilar Metal Welding

Tej Bahadur Rao
Department of Mechanical Engineering Monad University
Hapur, U.P.

Assoc. Prof. Vikas Kumar Tyagi
Department of Mechanical Engineering Monad University
Hapur, U.P.

Abstract Welding procedure can be performed on comparable or unique metals. Welding of disparate metals includes various kinds of metals with unmistakable compound piece. The two disparate metals include in welding procedure have diverse mechanical properties and microstructures which thus may influence welding parameters like weld current, hold time, weld power and so on. At the point when a structure or part of a machine is construct or experience any fix system this adjustment in substance arrangement of metals get unmistakable. The distinction in synthetic piece of metals might be because of a few factors, for example, age solidifying, oxidation and so forth. The investigation of mechanical properties of welding is significant in light of the fact that welded structure might be introduced at very delicate and hazardous spot. Issue of development of between metallic compound may emerge which influence the weld quality. In this paper a short survey has been given on the work done on mechanical portrayal, microstructure properties of welded joints.

Keywords- *Dissimilar metals, Microstructure, Mechanical properties, Inter-metallic, Welding, dissimilar welding, GTAW, Microstructure, Tensile strength, Bend test , Analysis..*

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I. INTRODUCTION

Welding is an assembling procedure of making a perpetual joint acquired by the combination of the outside of the parts to be consolidated, with or without the use of weight and a filler material. The materials to be joined might be comparative or not at all like one another. The warmth required for the combination of the material might be gotten by consuming of gas or by an electric circular segment. The last technique is all the more broadly utilized due to more noteworthy welding speed.

The cutting edge age requests quick creation of structures. Welding is an effective procedure where two materials whether of same or distinctive organization are combine for all time [1].Many mechanical/business structures are made of materials having diverse arrangement or in a similar welding method various properties are basic for various parts. These circumstances offer ascent to unique metal welds. A magnificent weld is what have satisfactory rigidity and flexibility with the goal that the joint which is framed to the welding of materials won't come up short [2].The serious issue that emerges when joining different metal welds is arrangement of between metallic compound in the welded locale. These between metallic mixes ought to be checked so as to discover issues identified with split affectability, malleability, erosion, and so forth which make the investigation of microstructure noteworthy. Investigation of between mettalic compound arrangement demonstrated that remaining anxieties are created in this area [3].

Welding, a metal joining procedure can be followed back in history to the antiquated occasions. In the Bronze Age, about 2000 years prior, roundabout boxes made of gold were welded in lap joint course of action by applying weight. Later on in the Iron Age, Egyptians began welding bits of iron together. In any case, welding as we probably am aware these days appeared uniquely in the nineteenth century.

II. WELD PROCESSES

The welding processes may be broadly classified into the following two groups:

1. Welding processes that use heat alone i.e. Fusion Welding.
2. Welding processes that use a combination of heat and pressure i.e. Forge Welding.

- Fusion Welding

In case of fusion welding the parts to be joined are held in position while the molten metal is supplied to the joint. The molten metal may come from the parts themselves i.e. parent metal or filler metal which normally has the same or nearly similar composition as that of the parent metal. Thus, when the molten metal solidifies or fuses, the joint is formed. The fusion welding, according to the method of heat generated, may be classified as:

1. Thermite Welding
2. Gas Welding
3. Electric Arc Welding

- Forge Welding

In forge welding, the parts to be joined are first heated to a proper temperature in a furnace and then hammered. Electric Resistance Welding is an example of forge welding. The principle of applying heat and pressure, either sequentially or simultaneously is widely used in the processes known as Spot, Seam, Projection, Upset and Flash Welding.

III. DISSIMILAR WELDING

Joining of dissimilar metals has found its use extensively in power generation, electronic, nuclear reactors, petrochemical and chemical industries mainly to get tailor-made properties in a component and reduction in weight. However efficient welding of dissimilar metals has posed a major challenge due to difference in thermo-mechanical and chemical properties of the materials to be joined under a common welding condition.

This causes a steep gradient of the thermo-mechanical properties along the weld.

A variety of problems come up in dissimilar welding like cracking, large weld residual stresses, migration of atoms during welding causing stress concentration on one side of the weld, compressive and tensile thermal stresses, stress corrosion cracking, etc. Now before discussing these problems coming up during dissimilar welding, the passages coming below throw some light on some of the causes of these problems.

In dissimilar welds, weldability is determined by crystal structure, atomic diameter and compositional solubility of the parent metals in the solid and liquid states. Diffusion in the weld pool often results in the formation of intermetallic phases, the majority of which are hard and brittle and are thus detrimental to the mechanical strength and ductility of the joint.

The thermal expansion coefficient and thermal conductivity of the materials being joined are different, which causes large misfit strains and consequently the residual stresses results in cracking during solidification.

IV. LITERATURE REVIEW

Throughout the years a ton of research has been done in the zone of disparate welding and many fascinating outcomes have been raised with respect to the issues experienced in unique welding. With disparate welding discovering its utilization in atomic, petrochemical, gadgets and a few other modern spaces, this segment brings into record crafted by the forerunners in this field.

Chengwu et al. [1] in their work on weld interface microstructure and mechanical properties of copper-steel different welding, the microstructure close to the interface between Cu plate and the intermixing zone was researched. Exploratory outcomes demonstrated that for the welded joint with high weakening proportion of copper, there was a change zone with various filler particles close to the interface.

Jiang and Guan [2] contemplated the warm pressure and lingering worry in disparate steels. They recommended that enormous remaining burdens are prompted by welding in the weld metal and warmth influenced zone (HAZ), which superimpose and increment the warm pressure.

Gyun Na, Kim and Lim [3] contemplated the remaining pressure and its expectation for different welds at atomic plants utilizing Fuzzy Neural system models. The elements that have an effect upon weariness quality are lingering pressure, stress focus, the mechanical properties of the material, and its miniaturized scale and large scale structure.

Gyun Na et al. [3] expressed that lingering pressure is one of the most significant factors yet its impact on high-cycle weakness is of more worry than different elements. Remaining pressure is a strain or pressure that exists in a material with no outside burden being connected, and the lingering worries in a segment or structure are brought about by contradictory inward lasting strains.

Welding, which is one of the most critical reasons for leftover pressure, commonly creates enormous pliable anxieties, the greatest estimation of which is around equivalent to the yield quality of materials that are joined by lower compressive remaining worries in a segment. [3] The remaining worry of welding can altogether hinder the presentation and dependability of welded structures. The honesty of welded joints must be guaranteed against exhaustion or consumption during their long use in welded segments or structures.

Khan et al. [4] contemplated laser pillar welding of disparate tempered steels in a filet joint setup and during the investigation metallurgical examination of the weld interface was finished. Combination zone microstructures contained an assortment of complex austenite ferrite structures. Neighborhood miniaturized scale hardness of combination zone was more noteworthy than that of both base metals.

Khan et al. [5] arrived at the resolution that arrangement of ferrite along the austenite grain limit in the warmth influenced zone on austenite side is watched. Simultaneously, microstructures are made out of two-stage ferrite and martensite with intra-granular carbide on ferrite side. Likewise the variety in nearby miniaturized scale hardness saw over the weld relies upon the division intermix of each base metal and the redistribution of austenite-and ferrite-advancing components in the weld.

Itoh et al. [6] got a patent on the joined structure on the unique metallic materials. This innovation relates for the most part to a joined structure of disparate metallic materials having various attributes. All the more explicitly, the development identifies with a joined structure of a current conveying contact or curving contact which are utilized for, e.g., a power breaker, or a covering end structure of a metal base and a covering material for improving conductivity and warmth obstruction.

Delphin, Sattari-Far and Brickstad [7] considered the impact of warm and weld leftover weights on CTOD (Crack Tip Opening Displacement) in flexible plastic break examination. They expressed that structures may come up short due to split development both in welds and in the warmth influenced zone (HAZ). The welding procedure itself initiates leftover worries in the weld and HAZ, which add to split development.

Delphin et al. [8] utilized a non-direct thermoplastic limited component model to reenact the circumferential weld in a moderately meager walled treated steel pipe. After the pipe had chilled off subsequent to welding a circumferential surface split was presented. The break, situated in the focal point of the weld, was exposed to two kinds of burdens. Right off the bat, the welded pipe was exposed to an essential tractable burden, and afterward to an auxiliary warm burden.

Delphin et al. [9] expressed that the decision of solidifying model is significant. It is accepted that kinematic solidifying is a superior decision than isotropic solidifying in low cycle recreations for example in a couple of pass welding process, as in the present examination.

Colegrove et al. [10] examined the welding procedure sway on lingering pressure and twisting. Their work tries to comprehend the connection between warmth input,

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combination region, estimated twisting and the remaining pressure anticipated from a straightforward numerical model, and the lingering stresses is approved with exploratory information.

V. Welding Methods

There are different methods of welding that are used to join dissimilar metals such as explosive welding, cold welding, ultrasonic welding, diffusion welding, friction welding, electron beam welding, arc welding and resistance spot welding.

Explosive welding is carried out by the relative movement of metal over one another. One of the metal pieces is accelerated at very high velocity by using some kind of explosive. Figure 1 show the explosive welding process. Some of the advantages of explosive welding are that it is a simple process, can join large surfaces, it will not affect the real and actual properties of metal. There are some limitations also such as it can only weld simple geometries, produced so much noise and large vibrations due to explosive[6].

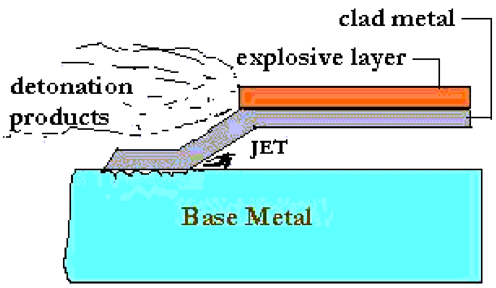

Figure 1. Explosive welding [6]

In cold welding, there is no heat used during welding process so, inter-mettaltic compound and heat affected zone formationis avoided. There are some limitations of cold welding like if the weld is exposed to oxygen rich environment, the oxygen will react with the weld and failure occurs[7].In ultrasonic welding, vibrations are used to weld dissimilar metals under pressure. This type of welding is mostly used for thin sheet of metals. Figure 2 show ultrasonic welding technique [8].

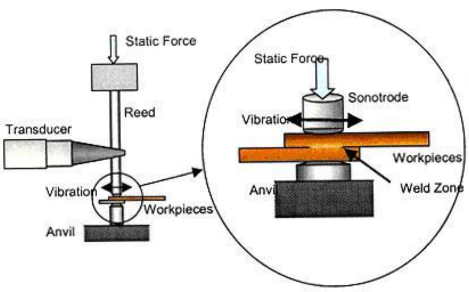

Figure 2. Ultrasonic welding [8]

Friction welding is performed by keeping one metal piece stationary while other metal piece is moved over the stationary piece to produced friction that welds the two metals together. A little amount of heat is generated through the process of friction welding. Figure 3 show friction welding technique [9].In diffusion welding, the atoms of one metal get diffused into the other metal. There is apparently no visible line of weld joint[7].Arc welding process is carried out by using electrode which melts the base metal and join them. This welding is further divided into several other types. Figure 4 show the process of tungsten gas arc welding[7].Beam welding is performed by using high electron beam and the welded region is very small. Figure 5 show process equipment for electron beam welding[7]. Resistance spot welding is performed by using heat which is produced from resistance to current. This heat is used to join two metal surfaces. The advantages of resistance spot welding are that it is a cheap process, it provide dimensional accuracy and high speed process. There are also limitation of the process such as the tensile strength and fatigue strength is low, increase he weight and hard to repair [7].

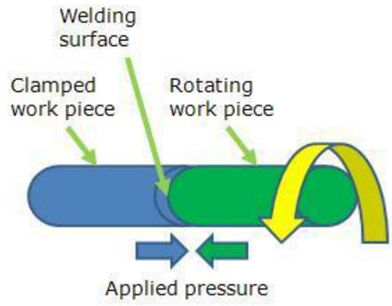

Figure 3.Friction welding [9]

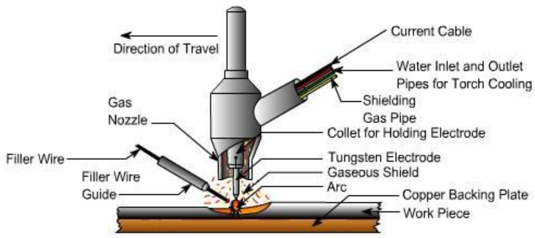

Figure 4. Gas Tungsten Arc welding [7]

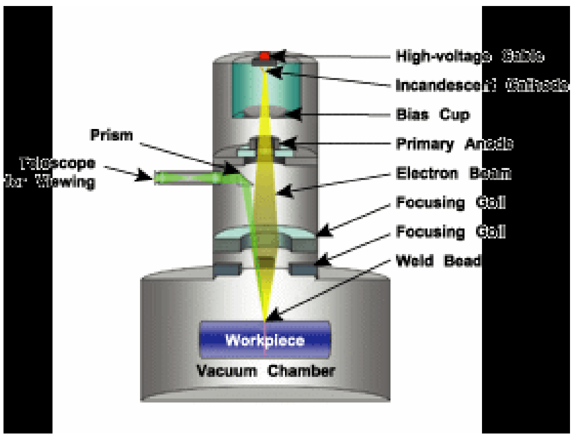

Figure 5. Electron beam welding [7]

VI. MICROSTRUCTURAL EVOLUTION

MUKUNA et al. worked on the dissimilar metal weld by taking aluminum and copper. The process of welding used is friction stir welding (FSW) technique. They focused on the study of microstructure, mechanical testing and tools which are used during welding process. Friction stir welding technique is used because this type of welding reduces solidification or liquefaction cracking. This is a type of solid state welding which provide more efficiency[11].

Previously, Friction Stir welding of copper and aluminum as not been studied widely except the study of material flow, welding parameters and their optimization. There is a room of improvement while developing their application in industries. According to the study of microstructure if on the advancing side we place copper plate it will provide god results. Some inter-metallic compound developed while this welding which need to be properly understands in order to have a clear view of their impact on the weldments. The optimization of the welding parameters will reduce the amount of inter-metallic compound formed. The friction stir welding will be the most used welding technique in the future but more understanding should be developed to enhance the mechanical properties of welds. If the tools used for friction stir welding improved then high quality welds can be produced[11].

VII. FORMATION OF INTERMETTALIC COMPOUNDS

YOON et al. studied that usually fusion welding is used for dissimilar meal welds. This welding technique fails when inter metallic compounds are formed or where temperatures of two materials don’t match or where the two materials involved have wide different melting points. In order to overcome all these problems friction welding technique is used [12]. A. AMBROZIAK worked on the friction welding by taking liquid and studied that by using liquid the joint area can be protected by atmospheric gases [13]. A. AMBROZIAK et al. worked on friction welding by taking tungsten-titanium joints [14].

AMBROZIAK et al. studied that friction welding was used to join dissimilar metals like aluminum-steel, steel-copper etc. The metals that are present in group IV, V and VI like titanium, vanadium, Zirconium etc can also be welded by friction welding process. The major that someone might have come across in friction welding is the development of inter metallic phases between two different metals. In order to overcome this problem intermediates layers of different elements are used. To study the effect of intermediate layers by using friction welding in dissimilar metals three combinations of materials is taken into account niobium-D18 pseudo-alloy of tungsten, titanium-D18 pseudo-alloy of tungsten, and steel-titanium. Pseudo-alloy are those alloy which are produced by powder-metallurgy technique, in which base is 95% and other bonding elements are mixed together to form the remaining 5% composition. Results shows when direct friction welding is used in the above three combinations inter metallic phases are formed and it is very hard and difficult to remove them. When the metallic intermediate layers are used no inter metallic phases are formed between the two different metals but when there is no micro crack developed in that area. For niobium-D18 pseudo-alloy of tungsten, copper as an intermediate layer can be used. For titanium joints vanadium intermediate layers have to be used [15].

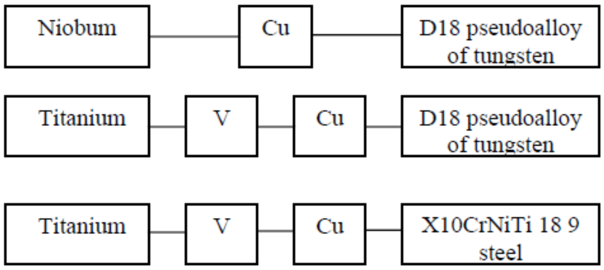

Figure 6.Inter layering system in niobium and titanium joints [15]

VIII. EXPERIMENTAL INVESTIGATION AND ANALYSIS OF DISSIMILAR WELDING OF AISI 316 L AND IS 2062 USING GTAW

Gas tungsten arc welding (GTAW), also known as tungsten inert gas (TIG) welding is an arc welding process that uses an non consumable tungsten electrode to produce the weld. The weld area is protected from atmospheric contamination by an inert shielding gas (argon or helium), and a filler metal is normally used. GTAW is most commonly used to weld thin sections of stainless steel and non-ferrous metals such as aluminum, magnesium, and copper alloys. The process grants the operator greater control over the weld than competing processes such as shielded metal arc welding and gas metal arc welding, allowing for stronger, higher quality welds. However, GTAW is comparatively more complex and difficult to master, and furthermore, it is significantly slower than most other welding techniques.

IX. FINITE ELEMENT ANALYSIS OF DISSIMILAR METAL JOINTS

The outcomes that are acquired after the weld reenactment can be taken considering . In the primary case AISI 309L treated steel has been taken as the weld filler metal whose properties are accepted equivalent to AISI 316L hardened steel which is one of the parent metals. So the outcomes induced from all the pressure followed up on it. Warm pressure has created inside the welded part as both of its closures over the weld have been fixed against any sort of movement by setting up in nodal dislodging every which way as zero. This is the limit conditions utilized in all regions.

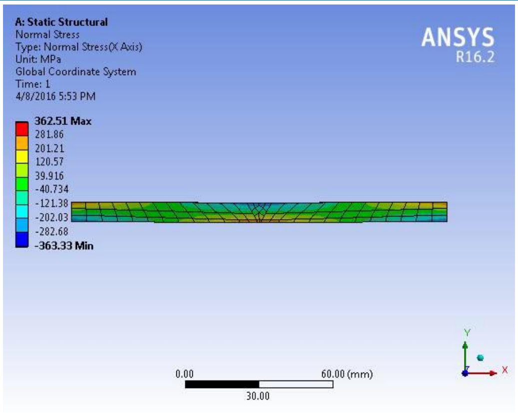

Fig 7. Normal stress contour of Model

The typical pressure changes from 362 MPa pliable to 363MPa compressive. The peak of the tensile lies along the centerline of the weld metal. Anyway peak of the compressive pressure lies in the weld interface of weld filler metal and IS 2062 mellow steel.(fig 7)

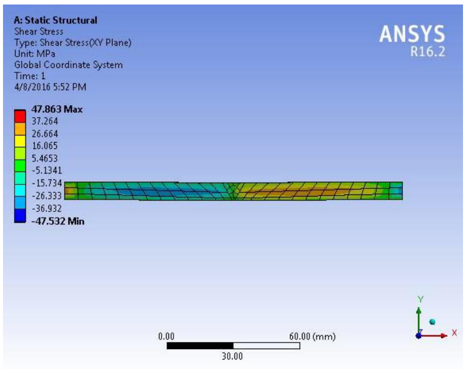

Fig 8 Shear stress contour of Model

The shear pressure differs from 478 MPa positive to 475 MPa negative. Anyway peak of the shear pressure lies in the weld interface of weld filler metal and 2062 gentle steel. From the over two cases it is exceptionally certain that the weld interface on the 2062 gentle steel is the most elevated hazard zone, where the disappointment is well on the way to happen. The shear pressure conveyance along the line P is appeared in Fig. 8

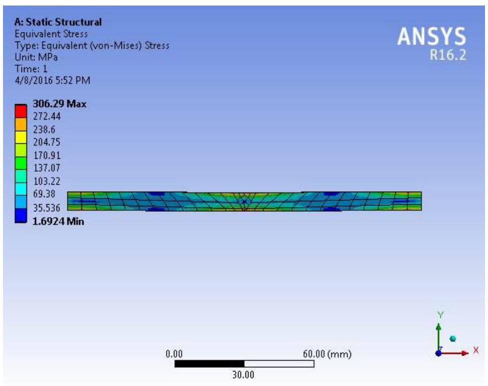

Fig 9 von-mises stress

The value of von-mises stresses developed in the welded joint in the model is 306 MPa of the tensile nature and 169 MPa of the compressive nature. The maximum tensile stress is located at the centre of the welded joint and is much localised.(fig 9).

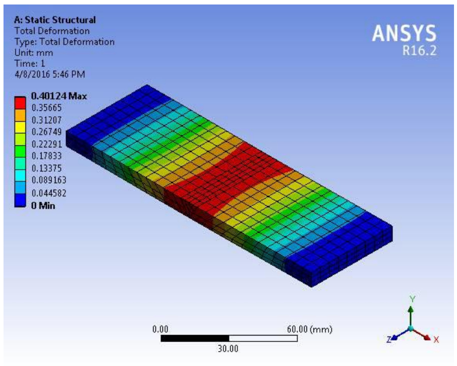

Fig 10 Total deformation

The total deformation result shows that tensile value in the weld joint to be 410 Mpa then the weld zone to be deformed. The total stress occurred in the center line of the weld joint (fig 10).

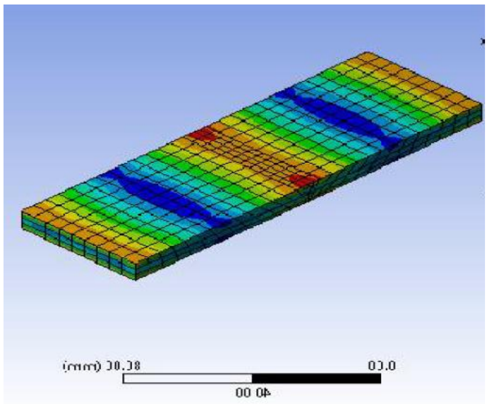

Fig 11 Equivalent elastic strain

The investigation of strain which is a parameter in choosing the defenselessness of stress consumption splitting is talked about in the following passage. In accordance with the anxieties the form of identical strain likewise portrays that a greatest strain of 0.001 m/m is additionally situated in the weld interface on the IS 2062 gentle steel side. This implies this interface has the most astounding twisting.

X. CONCLUSION

The ends which can be produced using the investigation are, various kinds of welding procedures can be utilized so as to weld disparate metals. Investigation of the mechanical properties of the weld is significant in light of the fact that the principle reason for the welding is to firmly combine the two metals as the use of the welded structure might be at touchy spot. It is critical to check the elasticity of the weld and the elements influencing the quality of the weld. The serious issue happens with unique metal welds is development of between metallic mixes at the interface which influence the properties and proficiency of the weld. So as to improve the quality of the different metals weld moderate layers at the interface can be utilized.

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