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Mechanical and Microstuctural Analysis of Dissimilar Metal Welding of AISI 316 L and IS 2062 Using GTAW

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Abstract Welding is widely utilized in manufacture as an elective strategy for giving or producing and a role as a substitution for shot and bolted joints. It is additionally utilized as a fix medium for example to rejoin a metal at a make or to manufacture laugh out loud a little part that has severed, for example, an apparatus tooth or to fix a well used surface, for example, a bearing surface.

In this research work, Joining of dissimilar metals has found its use extensively in power generation, electronic, nuclear reactors, petrochemical and chemical industries. This Experimental work investigates the technical considerations of dissimilar metal welding between IS2062 Grade C mild steel and 316L stainless steel using the GTAW process. Finite element analysis of dissimilar metal joints are also analyzed and compared with experimental work. Experiments are performed to study about the microstructure, Tensile strength and bending behavior of dissimilar metal 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, a metal joining procedure can be followed back in history to the antiquated occasions. In the Bronze Age, about 2000 years prior, round 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. Be that as it may, welding as we probably am aware these days appeared uniquely in the nineteenth century.

Sir Humphrey Davy created an electric circular segment utilizing two carbon terminals controlled by a battery. This guideline was in this manner connected to weld metals. Opposition welding at long last created in the year 1885by Elihu Thomson. Acetylene gas was found in 1836 by Edmund Davy, however it couldn't be utilized in welding application because of absence of an appropriate welding light. At the point when the require welding light was created in 1900, oxy-acetylene welding ended up one of the most famous kind of welding basically because of its generally lower cost. Anyway in the twentieth century it lost its place to curve welding in the greater part of the modern applications.

Advance welding systems like Plasma Arc Welding, Laser Beam Welding, Electron Beam Welding, Electro-Magnetic Pulse Welding, Ultrasonic Welding, and so forth are currently being broadly utilized in electronic and high exactness modern applications [5].

II. Welded Joints

The welding joint geometry can be classified primarily into five types. This is based on the orientation between the material surfaces to be joined. The various joints are shown in the figure 1 below:

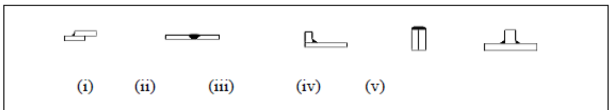

Fig 1: Types of Welded Joints

(i) Lap Joint
(ii) Butt Joint
(iii) Corner Joint
(iv) Edge Joint
(v) T-Joint

The main considerations involved in the selection of a particular welded joint are given below:

1. The shape of the welded component required,
2. The thickness of the plates to be welded, and
3. The direction of the forces to which the finished object will be subjected to in the actual working conditions.

III. Metallurgy of a Welded Joint

Metal is warmed over the scope of temperature up to combination and pursued by cooling surrounding temperature. Because of differential warming, the material far from the weld dot will be hot yet as the weld globule is moved toward continuously higher temperatures are gotten, bringing about a complex smaller scale structure. The ensuing warming and cooling brings about setting up inward anxieties and plastic strain in the weld.

Depending upon the slope of temperature gradient three distinct zones as shown in Fig. 2 can be identified in welded joint which are:

1. Base metal
2. Heat Affected Zone (HAZ)
3. Weld metal

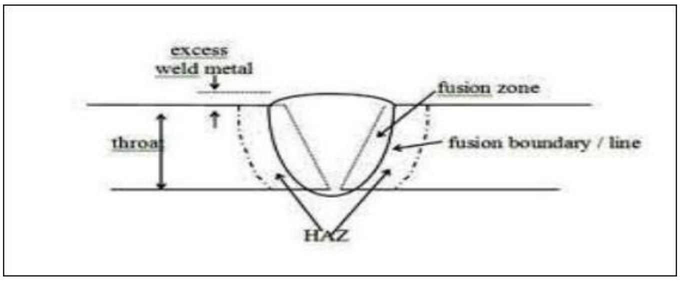

Fig 2: Zones in a welding joint

A joint produced without a filler metal is called autogenous and its weld zone is composed of re- solidified base metal. A joint made with a filler metal is called weld metal. Since central portion of the weld bead will be cooled slowly, long columnar grains will developed and in the out ward direction grains will become finer and finer with distance.

So the ductility and toughness decreases away from the weld bead. However strength increases with the distance from the weld bead. The original structure in steels consisting of ferrite and pearlite is changed to alpha iron. The weld metal in the molten state has a good tendency to dissolve gases which come into contact with it like oxygen, nitrogen and hydrogen.

So during solidification, a portion of these gases get trapped into the bead called porosity. Porosity is responsible for decrease in the strength of the weld joint. Cooling rates can be controlled by preheating of the base metal welding interface before welding.

The heat affected zone is within the base metal itself. It has a microstructure different from that of the base metal after welding, because it is subjected to elevated temperature for a substantial period of time during welding. In the heat affected zone, the heat applied during welding recrystallizes the elongated grains of the base metal, grains that are away from the weld metal will recrystallizes into fine equiaxed grains.

IV. STRESSES FOR WELDED JOINTS

The stresses in welded joints are difficult to determine because of the variable and unpredictable parameters like homogeneity of the weld metal, thermal stresses in the welds, changes in physical properties due to high rate of cooling, etc. In design problems, these stresses are obtained on the following assumptions:

1. The load is distributed uniformly along the entire length of the weld, and
2. The stress is spread uniformly over its effective section.

Residual Stress

Residual stress is a compression or pressure that exists in a material with no outer burden being connected, and the leftover worries in a part or structure are brought about by inconsistent inward changeless strains. Welding, which is one of the most critical reason for remaining pressure, commonly creates enormous tensile stresses, the greatest estimation of which is around equivalent to the yield quality of materials that are joined by lresidual stresses in a part. The remaining worry of welding can essentially hinder the exhibition and unwavering quality of welded structures.

Two of the serious issues of any welding procedure are lresidual stresses and distortion. Remaining pressure is principally brought about by the compressive yielding that happens around the liquid zone as the material warms and extends during welding. At the point when the weld metal cools it contracts which causes a tensile residual stress, especially in the longitudinal heading.

Thermal Stresses

In dissimilar metal welding, one of the metals in contact at the weld metal interface is constrained by expansion or contraction of the other. The two metals being welded possess different coefficient of thermal expansion. The metal having a higher coefficient of thermal expansion, with its tendency to expand more than the other is constrained by the fixed boundary. As a result of which compressive thermal stress is developed in the metal having a higher coefficient of thermal expansion while tensile thermal stress is developed in the metal with the lower coefficient of thermal expansion. The thermal stress developed during the welding is shown in Fig 3 (a).

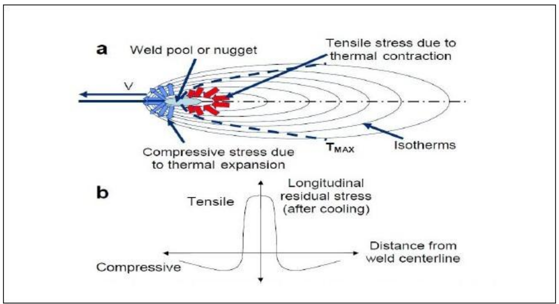

Figure 3: Stress in welds (a) thermal stress during & (b) residual stress after welding.

V. STRESS CORROSION CRACKING (SCC)

Stress corrosion cracking is splitting because of a procedure including conjoint consumption and stressing of a metal because of residual or applied stresses. The effect of SCC on a material as a rule falls between fatigue threshold and the exhaustion edge of that material. SCC more often than not happens in certain particular composite condition pressure mixes. SCC is an erosion instrument that requires the blending of a material with an exceptionally specific condition and the use of a ductile worry over a basic worth.

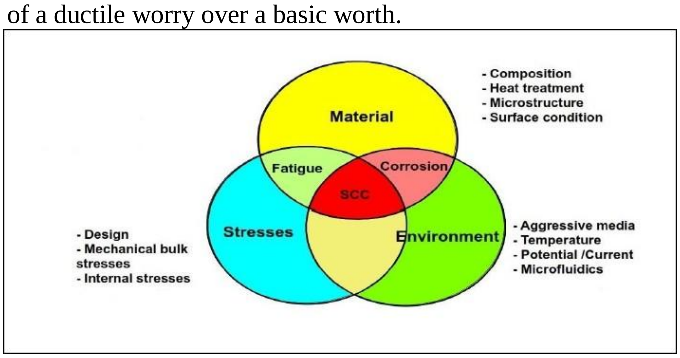

Fig 4: Factors influencing Stress Corrosion Cracking

As shown in Fig. 4 above Stress Corrosion Cracking is not just a material problem, but it is a combined result of the following three factors:

1. Material Properties
2. Corrosive Environment
3. Stresses

VI. LITERATURE REVIEW

To abridge the writing considered it must be said that the anxieties created in divergent welding are altogether different from these in comparable welding. Residual stress present in the weld metal and HAZ of parent metals makes the part entirely vulnerable to stretch erosion splitting. The leftover pressure, if not considered while planning the welded joint prompts an underestimation of the real anxieties and at last the part flops in its expressed administration life.

The writing likewise affirms that nickel based combinations show a superior elasticity, protection from carbon movement and lower strain solidifying than treated steels. So a nickel based alloy is increasingly appropriate to be utilized as weld filler metal for welding steels.

Throughout the years a ton of research has been done in the territory of Lundin [1] did his exploration on different welds with its accentuation on carbon relocation, stress/strain condition of welds and progress joint disappointment system. The investigation expressed that most of disappointments have been related with austenitic treated steel filler metal joints, and it is viewed as that the disappointment mode displayed by the nickel-based filler metals is on a very basic level not quite the same as that with the austenitic impeccable fillers.

Lundin [1] said that the breaking regularly starts at or close to the outside surface. The splitting outcomes straightforwardly from void linkup, grain limit detachment or tearing. It is commonly parallel to the weld interface. The splitting is related with or exacerbated by oxidation-oxide indenting. The relative development coefficients of the different weld metal locales are critical with respect to warm pressure age.

VII. MECHANICAL CHARACTERIZATION

SHUBHAVARDHAN et al. worked on joints of dissimilar metal welds by taking AA6082 aluminum alloy and AISI 304 stainless steel using friction welding. Different tests including impact test, tensile test, hardness test and fatigue test were conducted to find out different and optimized welding parameters. The test results showed that strength of joint varies with increasing pressure and time. When tensile test was conducted the results showed that in the start, strength of the joint increases but after reaching maximum value it decreases with increasing pressure and time. When temperature increases with time alloying element get deposited on the interface which make the weld strength decreased. Authors obtained better interface weld strength and improved fatigue strength by optimizing pressure and time[2].

TABAN et al. worked on the microstructure of interface which was done by the friction welding [3]. CHEN worked on the process parameters of friction stir welding and found the pieces of steel in weld zone [4]. OZDEMIR studied friction welding of dissimilar metal weld. The main combination used was AISI 304 L and AISI 4340 steel. These combinations were used in applications where certain special properties required and it also saves cost [5]. WATANABE et al. studied friction stir welding and showed a possible way to join the metal combination of aluminum and steel [6]. WATANABE et al. obtain the tensile strength of the joint of about 86% of aluminum base metal [7] after combining Aluminum to steel and SATHIYA et al studied about the friction time when the weld zone is fully plastically deformed [8].

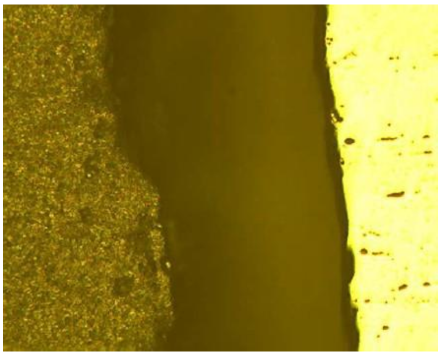

Figure 5. Interface region of dissimilar metal weld joint [2]

VIII. 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[21].

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[21].

IX. EXPERIMENTAL INVESTIGATION AND ANALYSIS OF DISSIMILAR WELDING OF AISI 316 L AND IS 2062 USING GTAWTENSILE TEST

T Chengwu et al. [21] in their work on weld interface microstructure and mechanical properties of copper-steel divergent welding, the microstructure close to the interface between Cu plate and the intermixing zone was examined. Test results demonstrated that for the welded joint with high weakening proportion of copper, there was a progress zone with various filler particles close to the interface. Be that as it may, if the weakening proportion of copper is low, the change zone is just created close to the upper side of the interface. At the lower side of the interface, the tempestuous blasting conduct in the welding pool prompted the infiltration of fluid metal into Cu. The welded joint with lower weakening proportion of copper in the combination zone showed tensile strength.

Jiang and Guan [22] examined the warm pressure and lingering worry in divergent steels. They recommended that huge leftover anxieties are initiated by welding in the weld metal and warmth influenced zone (HAZ), which superimpose and increment the warm pressure. Gyun Na, Kim and Lim [23] considered the remaining pressure and its forecast for different welds at atomic plants utilizing Fuzzy Neural system models. The components that have an effect upon weakness quality are remaining pressure, stress fixation, the mechanical properties of the material, and its small scale and full scale structure. They expressed that remaining pressure is one of the most significant factors yet its impact on high-cycle exhaustion is of more worry than different elements. Lingering pressure is a pressure or pressure that exists in a material with no outside burden being connected, and the remaining worries in a part or structure are brought about by contrary inside lasting strains.

Welding, which is one of the most noteworthy reasons for leftover pressure, ordinarily delivers huge malleable burdens, the greatest estimation of which is roughly equivalent to the yield quality of materials that are joined by lower compressive lingering worries in a part. The leftover worry of welding can essentially impede the exhibition and unwavering quality of welded structures. The uprightness of welded joints must be guaranteed against exhaustion or erosion during their long use in welded parts or structures. On stress consumption splitting expressed that pressure erosion breaking ordinarily happens when the accompanying three components exist simultaneously: vulnerable material, destructive condition, and malleable pressure including lingering pressure. In this manner, lingering pressure turns out to be basic for stress-consumption splitting when it is hard to improve the material destructiveness of the segments and their condition under working conditions.

Khan et al. [24] examined laser pillar welding of divergent treated steels in a filet joint arrangement 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. The welding combination zone microstructure comprises of generally essential ferrite dendrites with a between dendrites layer of austenite. This austenite shapes through a peritectic–eutectic response and exists at the ferrite cementing limits toward the finish of hardening. Some lathy ferrite morphology is additionally seen in this zone. This is because of confined dissemination during ferrite–austenite change that outcomes in a lingering ferrite design. They arrived at the resolution that development 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. Additionally the variety in nearby miniaturized scale hardness saw over the weld relies upon the portion intermix of each base metal and the redistribution of austenite-and ferrite-advancing components in the weld. Itoh et al. [25] got a patent on the joined structure on the unique metallic materials. This innovation relates for the most part to a joined structure of divergent metallic materials having various attributes. All the more explicitly, the creation 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 [26] 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 fall flat in light of split development both in welds and in the warmth influenced zone (HAZ). The welding procedure itself instigates remaining worries in the weld and HAZ, which add to split development. They utilized a non-direct thermoplastic limited component model to reenact the circumferential weld in a moderately slim walled hardened steel pipe. After the pipe had chilled off subsequent to welding a circumferential surface split was presented. The split, situated in the focal point of the weld, was exposed to two sorts of burdens. Right off the bat, the welded pipe was exposed to an essential elastic burden, and afterward to an optional warm burden. They 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 reenactments for example in a couple of pass welding process, as in the present examination. For the instance of weld leftover worries in mix with high warm anxieties, it is discovered that the versatility instigated by the warm burdens isn't adequate to stifle the impact of weld lingering weights on CTOD, notwithstanding for exceptionally high warm loads. The remaining burdens can be loose by emptying from an essential tractable burden.

Mai and Stowage [27] did their work on portrayal of divergent joints of steel-kovar, copper-steel and aluminum-copper. It was expressed in their work that joining of different materials is one of the difficult errands confronting present day makers. Unique metal welding innovations discover application in numerous areas, for example, smaller scale hardware, medicinal, optoelectronics and miniaturized scale frameworks. The minor geometry of the joints and the diverse optical and warm properties of the materials makes laser welding one of the most appropriate creation strategies.

X. TENSILE TEST

Fig 4.6 Tensile test specimen

Tensile testing was carried out using Universal Testing Machine of 400 KN capacity and the geometry of the test specimen is as shown in Fig. 4.1. Mechanical proprieties of GTAW welded dissimilar welds of stainless steel and mild steel after tensile test are tabulated in respectively. Tensile strengths of welded test samples vary from 394 to 457 MPa depending upon the welding conditions. All the specimens broke in the weld region and parentage of elongation measured across the weldment using an extensometer show ductility ranging from 4.9% to 6.6%. The variation of average values of ultimate tensile value, yield strength and percentage elongation for each test sample has been plotted.

Bend Test: Bend test is a simple and inexpensive test that can be used to evaluate both ductility and soundness of metal joints. The strain applied to the specimen depends on the diameter of the former around which the coupon is bent and this related to the thickness of the coupon 't', normally expressed as a multiple of 't' eg 3t, 4t etc. The former diameter is specified in the test standard and with the strength and ductility of the material the former diameter for a low ductility material such as a fully hard aluminium alloy may be as large as 8t.

Fig 7 Face bent of weld joint

Fig 8 Root bend of weld joint

XI. RESULT

In this Experimental work presents a study of mechanical properties in a dissimilar welding joint between IS 2062GrC mild steel and AISI 316L stainless steel, using AISI 309L filler rod. It increases the weld zone strength has been discussed. From the results above that arrive the following conclusions

The hardness survey revealed how the weld zone strength is increased as a result of base metal dilution. In addition, the HAZ of solutionized316L will increase in strength.

The weld tensile test indicated that a AISI 316L and IS 2062C dissimilar metal with AISI 309L as filler using GTAW process can be performed as a strength of 372 Mpa, normal tensile yield strength of MS about 200Mpa.It indicates it would increase the total yield strength of specimen.

Electron microscope shows the change of metal migration towards base metal .On studying fusion zone and HAZ of mild steel , Stainless steel on using AISI 309L have higher dilution of base metals in weld area . Hence, the welded area strength is better.

The bend test of AISI 316L and AISI 2062C dissimilar metal with AISI 309L as filler rod. Is haven't any visual defect, when using (4T -180 degree) bending angle. It shows, had better bending behavior.

XII. CONCLUSION

The conclusions which can be made from the study are, different types of welding processes can be used in order to weld dissimilar metals. Study of the mechanical properties of the weld is very important because the main purpose of the welding is to strongly join the two metals together as the application of the welded structure may be at sensitive place.

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