

MECHANICAL AND CORROSION BEHAVIOUR IN HAZ ZONE TIG WELDED CIRCULAR PIPES FOR OIL PIPELINES

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

By

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**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **VENKATA DURGA PRASAD MADDURI (38150063)**, **MAHINDRA KADARI (38150046)** who carried out the project entitled "**MECHANICAL AND CORROSION BEHAVIOUR IN HAZ ZONE TIG WELDED CIRCULAR PIPES FOR OIL PIPELINES**" under my / our supervision from November 2021 to May 2022

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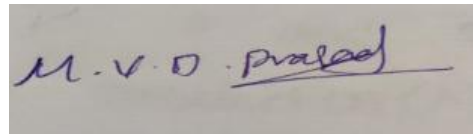
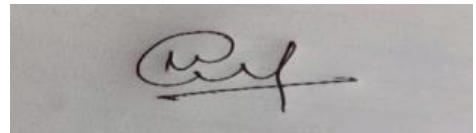
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DECLARATION

We., VENKATA DURGA PRASAD MADDURI (38150063) AND MAHINDRA KADARI (38150046) hereby declare that the project report entitled “**MECHANICAL AND CORROSION BEHAVIOUR IN HAZ ZONE TIG WELDED CIRCULAR PIPES FOR OIL PIPELINES**”, done by me under the guidance of Assistant Professor **Mr.V.SRIRAM, M.E., (Ph.D).** and **Dr. G. ARUNKUMAR, M.E., Ph.D.** at **SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY, CHENNAI** is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Mechanical Engineering.

A handwritten signature in blue ink that reads "M.V.D. Prasad" with a horizontal line extending from the end.A handwritten signature in black ink that appears to be "Arif" with a horizontal line extending from the end.

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I am pleased to acknowledge my sincere thanks to the Board of management of **SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY** for their kind encouragement in doing this project and for completing it successfully. I am grateful to them.

I convey my sincere thanks to **Dr. S. PRAKASH, M.E., Ph.D., Dean, School of Mechanical Engineering,** and **Dr. G. ARUNKUMAR, M.E., Ph.D., Head of the Department of Mechanical Engineering** for providing me the necessary support and details at the right time during the progressive reviews.

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ABSTRACT

The study is an investigation or examination of the oil pipelines for the mechanical and corrosional behaviour of the pipeline. The two different pipes are considered as ss304 and P91 each of them are for low flowing or lower velocity flowing liquids and higher flowing liquids. The metal properties are investigated after the heat is affecting the base metal from the tig welded heat. The ss304 is not most corrosional and has a good properties in every aspects for oil pipeline and P91 is one of the toughest metal which is more considered to oil transportation This study is an examination concerning the impact in Tungsten Inert Gas (TIG) welding of 304 austenitic tempered steel 1 mm and P91 Steel with 5mm thickness . Base materials were welded utilizing twofold sided single pass TIG welding technique, both with and without filler metal. There was a thorough investigation for the welding properties , including microstructure. mechanical properties and erosion conduct. The microstructure examination shows that interdendritic structure in SS304 and In P91 shows treated martensite in the welding metal for the two joints. The salt shower tests result was changes beginning load of the example subsequent to tesing for 24 and 48 hrs. In any case, the hardness tests results are great at both HAZ and Welded. Besides, there is no deficiency of weight for all joints

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LIST OF KEYWORDS

TIG-THUNGSTEN INERT GAS

SS304-STAINLESS STEEL 304

P91-P91 STEEL

HAZ-HEAT AFFECTED ZONE

DPH- DIAMOND PYRAMID HARDNESS

CHAPTER-1

INTRODUCTION

General

We have prepared the sample pipes of SS304 and P91 for the observation of corrosional and mechanical behaviour of the tig welded pipes. Initially the pipes were equally dismantled into two equal halves and welded with tig welding and made a decision of making of salt spray and Vickers hardness testing and microstructural images of the corrosional metal

1.1 SS304:

SS304 treated steel is the most widely recognized tempered steel. The steel contains both chromium (Cr) (somewhere in the range of 18%-20%) and nickel (Ni) (somewhere in the range of 8%-10.5%) metals as main non-iron constituent. And other components such as carbon, manganese, silicon, phosphorus, sodium, chromium, nickel, iron, nitrogen were a part of the material. An austenitic treated steel. As compared to carbon steel it is less conductive with electricity and heat. It is attractive, but less attractive than steel. It has a higher erosion resistance than ordinary steel and is broadly utilized on account of the simplicity in which it is framed into different shapes. 304 tempered steel has incredible protection from a wide scope of air conditions and numerous destructive media. It is prone to pitting and cleft erosion under warm chloride conditions and to elongation fracture above around 60 °C. It is viewed as impervious to pitting consumption in water with up to around 400 mg/L chlorides at encompassing temperatures, diminishing to around 150 mg/L at 60 °C. The carbon content of SS304 is limited to a limit of 0.08%. The melting point of the material is 1400-1450 °C and has a higher tensile strength of a range between 540-750 and the stress 230 MPa elongated length can be prolonged up to 45%.

1.2 P91:

The P91 steel is a 9Cr-1Mo ferritic alloy steel with intentional addition of vanadium and niobium, as well as controlled nitrogen content. Other minor material composition like nickel, manganese, silicon and carbon. It has extraordinary high temperature resistance and creep strength. It likewise has great protection from corrosion, oxidation and weakness break at raised temperatures. The P91 steel is principally utilized for superheater and reheater in power plant heater development, headers, fundamental steam pipeline, as well as the warming heater channeling in petrochemical industry. Contrasted with other austenitic alloy steels, it has better thermal conductivity and thermal expansivity. The melting point of the material is 1420°C and tensile strength 570-590 and has a low elongation property as 20%.

1.3.TIG WELDING

The Principle of TIG welding is an arc electric welding process in which the combined energy is taken by an electric arc dissipated between the work piece and the tungsten electrode. During the welding system the electrode, the arc and the weld pool are safeguarded against the harmful impacts of the climatic air by an inactive shielding gas. The movement of electrons from the tip of the electrode happens at an exceptionally rapid rate and when it hits the work piece a significant amount of heat is generated. Tungsten is the principle electrode of welding. Tungsten electrodes are accessible in various measurements from 0.5 to 8 mm. The most often involved aspects for TIG welding electrodes are 1.6 - 2.4 3.2 and 4 mm. The measurement of the electrode is picked on premise of the ongoing power, which kind of cathode that is liked and whether it is rotating or direct current. The electrode current is represented by the voltage represented by the end-of-travel changing a certain number of times, typically 100 times

each time . As indicated by the hypothesis of electrons the adversely charged electrons and decidedly charged particles will move when the circular segment is touched off.

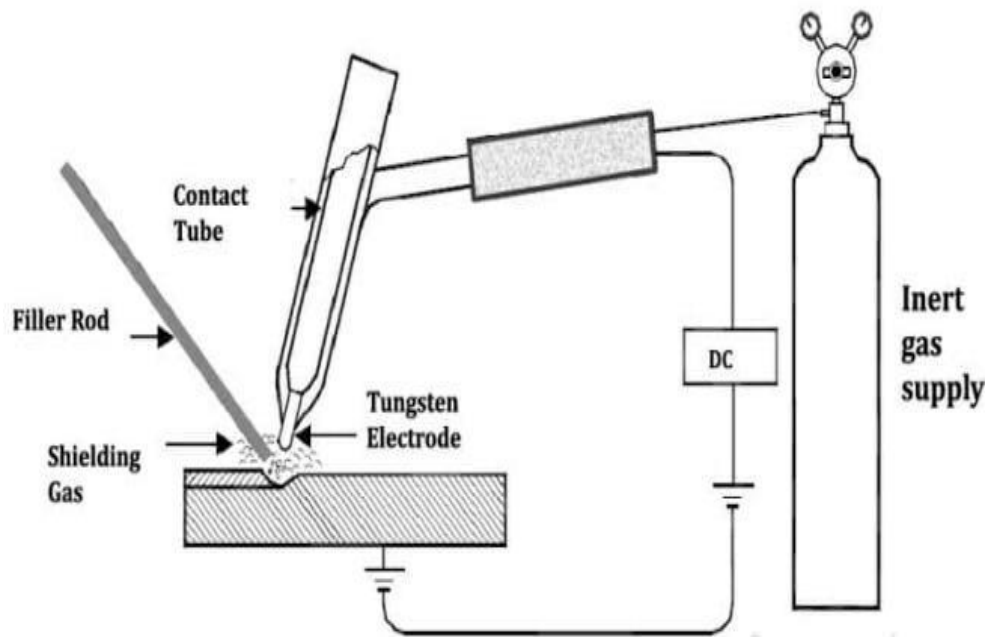


Fig:1.1:TIG Welding Setup

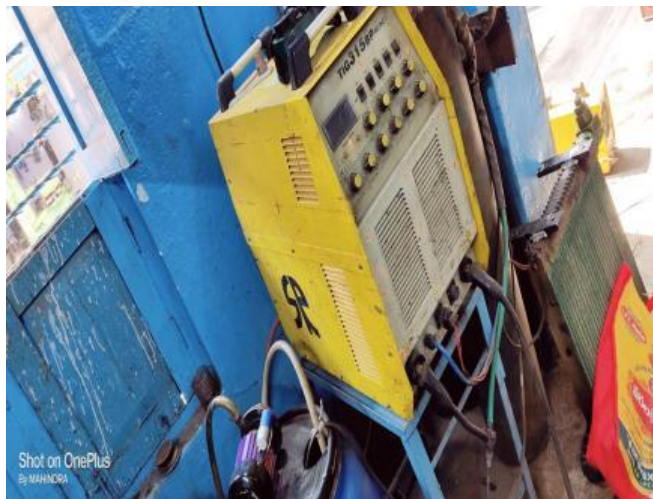


Fig:1.2: TIG Welding Machinery

The TIG welding hardware primarily comprises of machine arrangement as displayed in Fig.1.1. with the accompanying parts. A TIG torch that is the instrument the welder uses to control the bend. A power source which is fit for giving the vital welding current.

A TIG unit with joined control frameworks that make it conceivable to change the welding current, circular segment commencement and so forth. A protecting gas chamber with pressure decreasing valve and flowmeter. Fig.1.1. TIG welding machine arrangement. TIG welding process has an exceptionally huge area of utilization because of its many benefits like .It gives a concentrated warming of the work piece. It gives a viable insurance of the weld pool by a latent protecting gas. It tends to be free of filler material.

1.4.WIRE CUTTING:

It is the computer controlled process where the sample is extracted in very accurate way and desired dimensions. The work of the given machine is very precise and it is very slow process because it's very accurate. The wire cutting time depends on the thickness of the materials or sample. The electrode used in the machine is copper wire for cutting. The copper wire is electrically charged. The main objective is to do it because of no heat involved in doing it and in very accurate way of cutting .

During the EDM process, the metal part is placed in a dielectric liquid and the wire is inserted through the immersed metal part. Electric current is sent through the part to create sparks that ultimately help form the desired shape of the part. Reducing the separation distance between the electrodes increases the electric field strength and thus increases the strength of the dielectric fluid. Under these conditions, the current flows more easily between the two electrodes, leading to a separation of the element from the sheet at each spark. After the currents have passed and the desired shape is achieved, manufacturers sometimes perform a process called "rinsing", using a dielectric fluid to help remove any residual material or waste from the finished product.

1.5 HEAT AFFECTED ZONE(HAZ)

The hotness impacted zone (HAZ) is a non-liquefied area of metal that has gone through changes in material properties because of being presented to high temperatures. These progressions in material property are for the most part because of welding or high-heat cutting. The HAZ is the region between the weld or cut and the base (unaffected), parent metal.

1.6 MICRO VICKERS HARDNESS TEST

The Vickers hardness test was developed by Robert L. Smith and George E. Sandland at Vickers Ltd in 1921 as an option to the Brinell technique to measure the hardness of materials. The Vickers test is often easier to use than other hardness tests because the expected calculations are independent of the size of the indenter and the indenter can be used for all materials regardless of hardness. The basic guideline, as with all normal temper ratios, is to consider a material's ability to resist plastic twisting from a standard source. The Vickers test can be used for all metals and is probably the most extensive of all hardness tests. The unit of hardness given by the test is known as Vickers Pyramid Number (HV) or Diamond Pyramid Hardness (DPH). Hardness number can be converted to pascal units but should not be confused with pressure which uses similar units. Hardness, not quite set in stone by the heap, over the I-surface region of space and not the ordinary region of force, and in that sense is not pressure.

1.7 SALT SPRAY TESTING

The salt spray test is an accelerated corrosion test used to measure the comparative corrosion resistance of materials exposed to high temperature salt spray or salt fog. This corrosion test is intended to provide information on the corrosion resistance of metals and coated metals. Visual inspection after this test can determine the suitability of coatings, paints and metals against corrosion or exposure to marine environments. The salt spray test is also called as ASTM B117 and Fog test.

The salt spray test is used for:

Describe the corrosion resistance of various metals or surfaces. Measure the tendency to corrode when a metallic or coated surface is scratched. Determine coating adhesion and corrosion creep. Evaluation of corrosion resistance in marine environment (wet, temperature, salt spray)

Salt spray tests are popular because they are well standardized and rationally repeatable. Salt spray tests are commonly used to evaluate the corrosion resistance of parts or finished surfaces in some areas like industry, marine, automobile and aircraft and military equipment.

1.8 HAZ AREAS

While the HAZ happens between the weld or cutting zone what's more, the unaffected parent metal, the HAZ itself has various regions as per that they are so near where the cutting or welding heat was applied to the material.

The cutting or weld zone is simply the fluid district where the cycle happens and is abutted by the combination limit. The combination limit is the line of the combination zone where the fluid and strong periods of the metal coincide. Further from the weld or cutting zone is simply the HAZ, which is the place where the non-softened parent metal has encountered changes to the microstructure. In regular prepares, the HAZ can be separated into the grain, coarsened zone (nearest to the warmed region), the grain refined zone, the somewhat changed (intercritically warmed) zone and the tempered zone. In different materials, which don't go through a strong state stage change during cooling, it is normal to see a grain development zone and a recrystallized zone, with some proof of a tempered zone. Outside of these HAZ regions is the unaffected base material.

The different HAZ regions are framed by contrasting temperatures in the base metal further from the weld or cut itself. This ought not be confused with the series of apparent shaded groups, brought about by surface oxidation, almost a weld in hardened steel. The attitude tones address a lot of lower temperatures than those which structure the hotness impacted zone, and stretch out for some distance past the genuine hotness

impacted zone. These various varieties, otherwise called heat color, offer a surmised sign of the temperature came to by the metal For the situation of treated steel type 1.4301 (AISI 304) warmed in outdoors, the band tones and related temperatures are as per the following

<i>Yellow</i>	<i>370 °C</i>
<i>Brown</i>	<i>390 °C</i>
<i>Blue</i>	<i>540 °C</i>
<i>Dark blue</i>	<i>600 °C</i>
<i>Purple brown</i>	<i>420 °C</i>
<i>Dark purple</i>	<i>450 °C</i>
<i>Light yellow</i>	<i>290 °C</i>
<i>Straw yellow</i>	<i>340 °C</i>

Table 1.8:HAZ Regions Temperatures

The hotness color tones rely upon the material's protection from oxidation, with those metals with a higher steel chromium content appearance less serious colouration as they are more impervious to oxidation. The utilization of defensive gas and cathode coatings can likewise diminish heat color as they to some degree safeguard the metal from oxidation. Then again, harsher surfaces oxidize quicker, causing hazier varieties. Likewise, paint, oil, rust and even fingerprints can modify the hotness color, despite the fact that they don't affect the degree of the HAZ itself, The microstructure of PM was of treated strip martensitic structure, with communicated grain limits Carbides of M₂₃C₆ type, where the metal component was generally chromium (Cr), were scattered on earlier austenite grain limits Average grain size was 20 µm

1.9 SIMULATION OF HAZ

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Reenactment of HAZ created in single pass weld-ing method of P91 steel was performed by the SMITWELD 1405 warm test system Various welding cycles were explored by utilizing the 10 x 10 x 55 mm square examples. Temperatures of trademark material changes happening during the welding still up in the air from a dilatometric bend, were trademark change temperatures were $A_{ct} = 857\text{ }^{\circ}\text{C}$ and $A_c\ 914\text{ }^{\circ}\text{C}$ The material was warmed at a pace of $150\text{ }^{\circ}\text{C/s}$ During the cooling, development of martensite began at temperature of $403\text{ }^{\circ}\text{C}$, and was finished at $317\text{ }^{\circ}\text{C}$. Various districts of HAZ were delivered by reenacting single-pass welding at fourteen unique temperatures, going from $1300\text{ }^{\circ}\text{C}$ to $600\text{ }^{\circ}\text{C}$ Some of those outcomes are introduced in this paper The tensite to austenite was seen at reproduction gum based paint tures in the scope of $825\text{ }^{\circ}\text{C}$ to $875\text{ }^{\circ}\text{C}$ Figure 3 (c) shows the halfway change of starting tempered martensite. to austenite Peak temperature was among A_{cs} and A_{ct} change temperatures for P91 steel The marten-site was subsequently tempered during the PWHT Finally, the microstructure displayed in Figure 3 (d) was uniform consisting of tempered strip martensite, and was near the microstructure of unaltered parent material in which no apparent changes in constituents morphology happened

1.10 CHEMICAL AND CORROSION TEST

The salt shower test is a normalized and famous consumption test strategy, used to actually look at erosion opposition of materials and surface coatings. Normally, the materials to be tried are metallic (albeit stone, ceramics, and polymers may likewise be tried) and wrapped up with a surface covering which is expected to give a level of consumption insurance to the hidden metal

Salt splash testing is a speed up erosion test that creates a destructive assault to covered examples to assess (for the most part relatively) the reasonableness of the covering for use as a defensive completion. The presence of erosion items (rust or different oxides) is assessed after a pre-decided timeframe. Test term relies upon the consumption obstruction of the covering; for the most part, the more erosion safe the covering is, the more drawn out the time of testing before the presence of erosion or rust.

1.11 Application

Salt splash testing is famous in light of the fact that it is generally cheap, fast, very much normalized, and actually repeatable. In spite of the fact that there might be a powerless relationship between's the length in salt shower test and the normal existence of a covering in specific coatings, for example, hot-plunge stirred steel, this test has acquired overall prominence because of minimal expense and fast outcomes. Most Salt Spray Chambers today are being utilized NOT to foresee the erosion opposition of a covering, however to keep up with covering cycles, for example, pre treatment and painting, electroplating, stirring, and so forth, on a near premise. For instance, pre-treated + painted parts should pass 96 hours Neutral Salt Spray, to be acknowledged for creation. Inability to meet this prerequisite suggests precariousness in the compound course of the pre-treatment, or the paint quality, which should be tended to promptly with the goal that the impending bunches are of the ideal quality The more drawn out the speed up erosion test, the more extended the cycle stays crazy, and bigger is the misfortune as non-adjusting clumps. The main use of the salt shower test

is, thusly, empowering speedy correlations with be made among genuine and expected consumption opposition. Most normally, the time taken for cides to show up on the examples under test is contrasted with assumptions, to decide if the test is passed or fizzled. For this explanation, the salt splash test is most frequently conveyed in quality review job, where; for instance, it tends to be utilized to check the adequacy of a creation cycle, like the surface covering of a metallic part. The salt splash test has little application in foreseeing how materials or surface coatings will oppose persistent in reality, since it doesn't make, recreate or speed up certifiable destructive circumstances. Cielic statsion testing is more qualified to this.

1.12 Testing equipment



Fig:1.3:A salt spray cabinet

The mechanical assembly for testing comprises of a shut testing bureau/chamber, where a salt water (5 % NaCl) arrangement is atomized through shower nozzle(s) utilizing compressed air. This creates a destructive climate of thick salt water haze (likewise alluded to as a fog or shower) in the chamber, so that test tests presented to this climate are exposed to seriously destructive circumstances. Chamber volumes change from one provider to another. In the event that there is a base volume expected by a specific salt splash test standard, this will be plainly expressed and ought

to be agreed with. There is an overall recorded agreement that bigger chambers can give a more homogeneous testing climate.

Varieties to the salt splash test arrangements rely on the materials to be tried. The most well-known test for steel based materials is the Neutral Salt Spray test (frequently shortened to NSS) which mirrors the way that this sort of test arrangement is ready to an impartial pH of 6.5 to 7.2. Results are addressed for the most part as testing hours in NSS without appearance of erosion items (for example 720 h in NSS as per ISO 9227) Synthetic seawater arrangements are likewise generally indicated by certain organizations and principles. Other test arrangements have different synthetic substances added including acidic corrosive (frequently abridged to ASS) and acidic corrosive with copper chloride (frequently shortened to CASS) every one picked for the assessment of beautifying coatings, for example, electroplated copper-nickel-chromium, electroplated copper-nickel or anodized aluminum These fermented test arrangements for the most part have a pH of 3.1 to 3.3

A few sources don't suggest utilizing ASS or CASS test cupboards reciprocally for NSS tests, because of the gamble of cross-tainting. It is guaranteed that an intensive cleaning of the bureau after CASS test is truly challenging. ASTM doesn't resolve this issue, yet ISO 9227 doesn't prescribe it and assuming it is to be done, advocates a careful cleaning .Albeit most of salt shower tests are nonstop, Le the examples under test are presented to the persistent age of salt haze for the whole span of the test, a couple don't need such openness. Such tests are ordinarily alluded to as changed salt splash tests. ASTM G85 is an illustration of a test standard which contains a few altered salt shower tests which are varieties to the essential salt splash test

1.13 MICROSTRUCTURE ANALYSIS

The microstructure of AISI 304 austenite treated steel created by the slender strip projecting interaction were examined utilizing optical magnifying lens, filtering electron magnifying lens (SEM), transmission electron magnifying instrument (TEM), and X-beam diffraction (XRD) The microstructures of the projecting strips show a duplex design comprising of delta ferrite and austenite. The volume part of the delta ferrite is

around 9.74vol% at the middle and 6.77vol% at the outer layer of the projecting meager strip, in vermicular and band shapes. By virtue of fast cooling and hardening in the persistent projecting cycle, numerous sorts of incorporations and hastens have been found. The majority of the incorporations and accelerates are round complex mixtures comprising of oxides, for example, SiO_2 , MnO , Al_2O_3 , Cr_2O_3 , and FeO or their variety oxides of MnO , Al_2O_3 , 2FeO-SiO_2 , and 2MnO-SiO_2 . Many imperfections including disengagements and stacking shortcomings have additionally shaped during the fast cooling and hardening process, which is useful to work on the mechanical properties of the projecting strips

CHAPTER-2

LITERATURE SURVEY

M. V. Kuppusamy ET.AL., All the welded tests showed an austenite microstructure with some measure of δ -ferrite. The δ -ferrite showed interdendritic highlights and decreased with thickness from 6 mm-weld to 3 mm weld metal. The lathy and skeletal elements inside austenite were also apparent. The microhardness worth of the welded district close to the base metal area showed greatest value, attributed to the higher level of δ -ferrite present near to HAZ. The hardness esteem was greatest for 6-mm-thick welded test

Pradip Kumar ET.AL., Welded joints of disparate metals are in many cases expected in atomic and compound ventures. Among the different sorts of material mixes, welded joint of austenitic hardened steel and martensitic treated steel is one great choice. Because of contrasts in mechanical, metallurgical and erosion properties between the two disparate materials, determinations of reasonable welding boundaries, filler materials, safeguarding gas combination and so on are critical to keep away from uncommon warm angle, henceforth huge welding mutilations. In the current work, imperfection free TIG welding of unique materials AISI 304 has been made effectively.

Nature of the welded joint has been decided through pliable test, microstructural examination, miniature hardness estimation, conduct of the welded joint at various groupings of NaCl has been estimated through potentio-dynamic polarization. Weldment shows aloofness at various arrangements.

Akhilesh Kumar Singh ET.AL., The goal of this future-arranged structure plans a machine-stand that can-do various utilizations of tasks in a single machine outline segment stand is effectively manufactured subsequent to thinking about all the important security factors and trails likewise have done on cutting, boring and crushing activities according to need of works. By and large, we have seen that in conventional machines really do generally accomplish vigorously work as per the limit of the machine and because of nonstop in help they need support, fix, and supplanting parts yearly which builds the expense. If a machine in under upkeep, understudies, specialists, and scientists research-works halted. While noticing such an issue this machine-stand is created to work with flimsy or thick examples without layered misfortune and to accomplish high precision which was effectively manufactured at low making costs, a kind of hardware gear bought cost and low stock expenses for the examination arranged works (for example penetrating, cutting, and crushing) purposes has effectively have been accomplished.

Jayant Gopal Thakare ET.AL., The microstructural advancement and mechanical properties of gas tungsten curve welded creep strength improved martensitic (CSEM) and austenitic hardened steel (SS) different welded joint is investigated in the as welded (AW) and post weld heat treated (PWHT) conditions. The as gotten standardized and tempered P91 steel has been welded with SS304 L by setting up a regular section and utilizing a P91 GTAW filler wire. The welded plate is exposed to PWHT at 760 °C for 120 min followed via air cooling. The P91 steel in as gotten condition shown completely martensitic (tempered) structure with machine morphology and earlier austenite grain limits while SS304 L have austenitic design with twins. The heterogeneity (as-welded condition) across the welded joint were created as far as microstructure and mechanical properties (hardness, Charpy durability and rigidity). The variety in mechanical properties has been limited after the PWHT. PWHT has noticed a radical effect on

mechanical properties and microstructure of weld combination zone and HAZ of P91 side nonetheless, stay unaffected for the SS304 L side HAZ. The strength of the welded joint have been estimated 1016 ± 2.5 MPa and 906 ± 6.5 in as-welded and PWHT condition with joint effectiveness of 140 % and 125 %, individually.

Bandar Al-Mangour ET.AL., Stainless steel, a class of ferrous alloys, is notable for their protection from erosion, creep and high temperature applications. Because of expanding request of powder metallurgy compenents produced using treated steel in assortment of utilizations, including aviation, car, substance handling and biomedical field, it happened to an extraordinary interest

CHAPTER-3

AIM AND SCOPE OF THE PRESENT INVESTIGATION

3.1 AIM

The primary aim of the paper is to study the MECHANICAL and CORROSION BEHAVIOUR IN HAZ ZONE TIG WELDED CIRCULAR PIPES FOR OIL PIPELINES with SS304 and P91 materials and to study Hardness test , saltspray test and microstructural analysis

3.2 SCOPE

The Scope of this is the point by point perception on the SS304 and P 91 Materials with TIG Welded joints and what these materials perform at Heat Meant for Zone(HAZ) We Done different tests like Vicker's Hardness Test Salt Spray Test and Microstructural investigation on both the materials and these outcomes will assist many, this examination work with willing definetly helps for greatest oil pipelines MNC's as well as different Organizations.

CHAPTER-4

EXPERIMENTAL OR MATERIALS AND METHODS

4.1 MATERIALS

1.SS304 PIPE

DIMENSIONS :Outer Diameter-72mm,Thickness-1mm,Length-20cm

2.P91 PIPE

DIMENSIONS:Outer Diameter-72mm,Thickness-5mm,Length-20cm

3.TIG WELDING MACHINE

4.WIRE CUTTING MACHINE

5.VICKER`S HARDNESS MACHINE

6.SALTSPRAY TESTING EQUIPMENT

7.MICROSCOPY IMAGE VIEWER

METHODS

4.2 SHEET BLADE CUTTING

This cutting is taken because of low heat is involved while cutting the sample. Initially the sample was taken and cleaned and marked the length until where the sample should be cut for getting a better equal halves. The pipe is placed in the machine between the blade sheet and fixed the position of the blade sheet on the markings. The machine got started and the water is passing on to the sample through a small pipe because to make the sample less thermal and a rapid cutting process and to reduce the friction between the blade sheet and sample. The blade is rotating with the help of gears located both side of the sample after a quicker time (5min) the sample were cut with higher accurate values



Fig:4.1: Sheet Blade Cutting Machine

4.3 TIG WELDING

Tig Welding is also known as gas tungsten arc welding where the non consumable electrode is placed in the welding holder to generate the arc between the work piece and tungsten electrode which makes sample thermally melt and weld with the composition of tungsten here the inert gas is used for atmospheric gases not to react with the welding metal or sample

In the process of welding the sample were cool down for sometime after blade sheet cutting has been done then there is a v shaped base which is kept under the sample and the sample kept over it . The sample were connected with a wire which is passing through the tungsten welding machine then the filler metal and electrode are sharpened with cutting machine placing it horizontal. Then the welding process has been started and Inert gas has been manually released to protect the welding sample from oxidation process from the atmospheric gases like oxygen. The filler material wasn't used because the thickness is less than 6 mm so the samples are done tig welding



Fig:4.2:TIG Welding



Fig:4.3:TIG Welded pipe

4.4 WIRE CUTTING

It is the computer controlled process where the sample is extracted in very accurate way and desired dimensions. The work of the given machine is very precise and it is very slow process because it's very accurate. The wire cutting time depends on the thickness of the materials or sample. The electrode used in the machine is copper wire for cutting. The copper wire is electrically charged. The main objective is to do it because of no heat involved in doing it and in very accurate way of cutting .

During the EDM process, the metal part is placed in a dielectric liquid and the wire is inserted through the immersed metal part. Electric current is sent through the part to create sparks that ultimately help form the desired shape of the part. Reducing the separation distance between the electrodes increases the electric field strength and thus increases the strength of the dielectric fluid. Under these conditions, the current flows more easily between the two electrodes, leading to a separation of the element from the sheet at each spark. After the currents have passed and the desired shape is achieved, manufacturers sometimes perform a process called "rinsing", using a dielectric fluid to help remove any residual material or waste from the finished product.



Fig.4.4. Samples

4.5.EXPERIMENTS

4.5.1. Vicker's Hardness test

The Vickers test is frequently more straightforward to use than other hardness tests since the expected estimations are free of the size of the indenter, and the indenter can be utilized for all materials regardless of hardness

After the process of wire cutting the sample required for Vickers hardness test is $20 \times 20 \text{ mm}^2$ square piece for the test. As we have observed some of the parts of Vickers hardness testing machine is handwheel, indenter (diamond tip), screen with markings microscope, load selection screen

When the material sample is kept on the hand wheel area which is located to place the sample rotate the hand wheel to the clockwise in such a way that the point where the hardness needed to find and make the diamond tip indenter to get contact with and give the dwell time and check the load to get applied the dwell time we followed was 10 seconds and 50 kg of weight and start the process and wait until the dwell time ends and after that remove the indenter in contact with the sample and measure the length and calculate the HV

Repeat the experiment at both haz zone and welded area for both ss304 and P91 steel

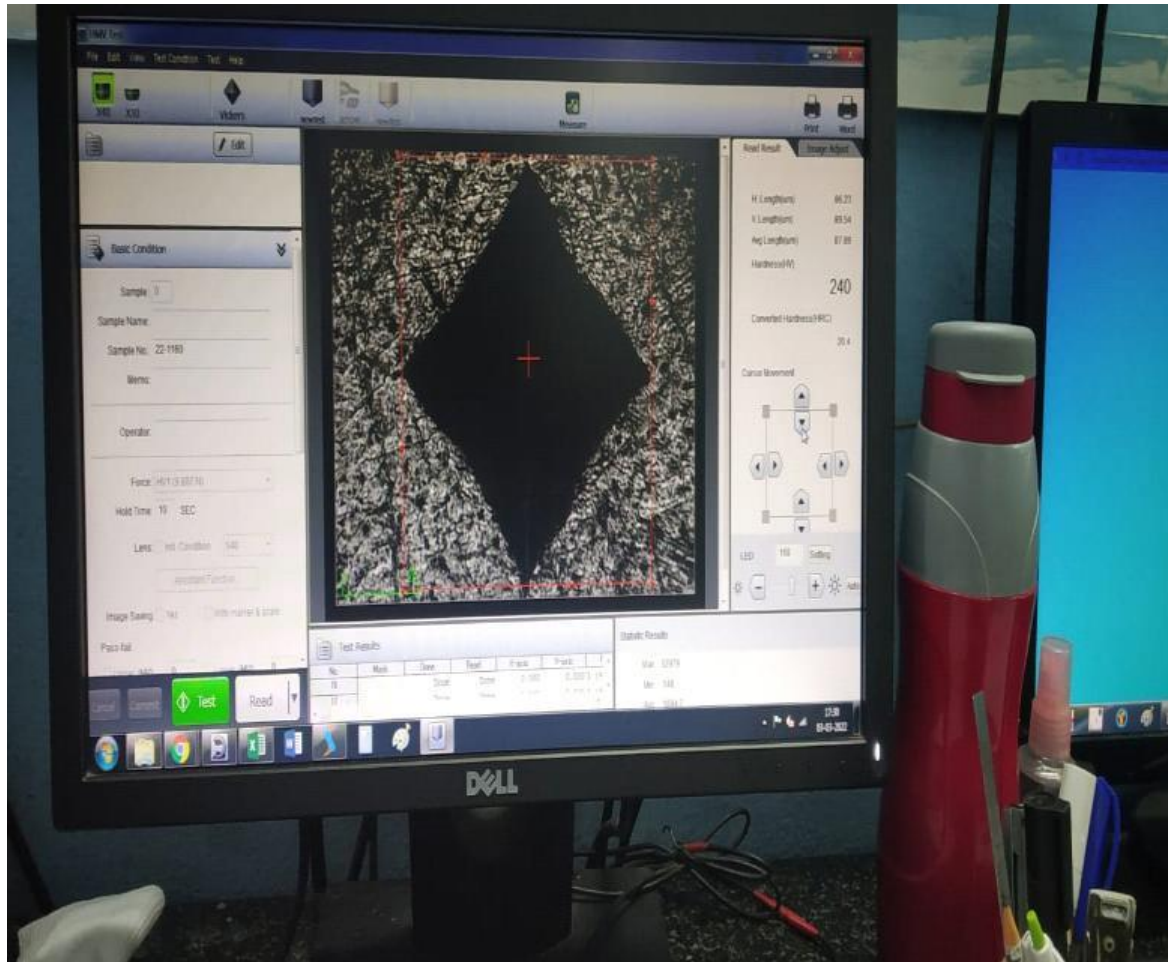


Fig:4.5: Microscopic Images

4.5.2. SALT SPRAY TEST

In the process of salt spray test an accelerated corrosive attack is given to the sample in order to find the portrait sample suitable in use of protective finish

This salt water is spread over the given samples through spray nozzle. the saltwater generates the corrosive environment of dense saline fog to emulate a corrosive experiment then the salt sprayed sample is kept

In the testing chamber under some basic characteristics with the concentration of solution of sodium chloride. Before the weight of the sample is checked to find the rate of corrosion happened and after the time period of the corrosion test they will check again the weight of the sample to find the rate of corrosion

The results are given as red rust was observed at the end of time period

CHAPTER-5

RESULT AND DISCUSSIONS

RESULT:

5.1 MICRO VICKERS HARDNESS TEST

The Vickers hardness test was fetched successfully at two points of the metal at the welded area and heat affected area (A centimetre away from the welded area). The hardness test was carried out for both the metal as a comparison of it. the tests were done at the test load of 50kgf

5.1.1. HAZ ZONE:

The three investigation are taken at every area and on every material for ss304 the readings are as here 233, 239 and 238 the penetrated depth at the hardness are 19, 20, 20. For P91 steel the readings are 275, 263, 269 and the penetrated depth at the hardness is 27, 25, 26 subsequently.

5.1.2. WELDED AREA:

The three investigation are taken at every area and on every material for ss304 the readings are high than the haz zone as 251,244,240 and the penetrated depth at hardness are as 22,21,20. For P91 steel the readings are even high as compared to ss304 the readings are 375 ,375,372 and the penetrated depth at the hardness is equal at every point and noted as 38.

MATERIAL:SS304

S.NO	LOCATION	HARDNESS IN HV1	EQNT HRC
1	HAZ	233,239,238	19,20,20
2	WELD	251,244,240	22,21,20

Table 5.1.1:Hardness Test values for SS304

MATERIAL:P91

S.NO	LOCATION	HARDNESS IN HV1	EQNT HRC
1	HAZ	275,263,269	27,25,26
2	WELD	375,375,372	38,38,38

Table5.1.2: Hardness Test values of P91

5.2 CORROSION TEST:

Material Used:P91

Tested time:24hrs

Here the metal was exposed to the corrosion test for 24hrs at certain conditions such as chamber temperature ranging from 33-37°C and pH of the solution from 6.5-7.2 and air pressure ranging from 12-18psi and the concentration of sodium chloride of 4-6% and collection of solution per hour is between 1-2ml in this certain conditions the P91 steel was investigated and there is a loss of weight

in the material of 0.0308. therefore the corrosional behaviour in the metals is existing. The microstructural images are taken when the corrosion occurred

The corrosion rate occurred is $0.0308/(1)^2=0.0308$

SL.NO	TEST CONDITION	REQUIREMENTS	ACTUAL
1	Chamber Temperature	35_+2^0C	33.9-34.8^oC
2	PH of solution	6.5 to 7.2	7.0
3	Air Pressure	12 to 18psi	15psi
4	Concentration of sodium chloride	5_+1%	5.0 - 5.2%
5	Collection of solution per hour	1 to 2 ml	1.2
6	Test hours	24hrs	24hrs

Note:Red rust observed at welded area at the end of 24 hrs

The photograph taken is exhibited as below:

Sample	
Initial Weight	Final Weight
38.9559g	38.9851g

Table 5.2.3: Corrosion Test values of P91 for 24hrs

Material Used:P91

Tested time:48hrs

Here the metal was exposed to the corrosion test for 24hrs and 48 hrs at certain conditions such as chamber temperature ranging from 33-37°C and pH of the solution from 6.5-7.2 and air pressure ranging from 12-18psi and the concentration of sodium chloride of 4-6% and collection of solution per hour is between 1-2ml in this certain conditions the P91 steel was investigated and there is a loss of weight

in the material of 0.0940. therefore the corrosional behaviour in the metals is existing. The microstructural images are taken when the corrosion occurred

The corrosion rate occurred is $-0.0940/(1)^2 = 0.0940$

SL.NO	TEST CONDITION	REQUIREMENTS	ACTUAL
1	Chamber Temperature	35_+2^oC	33.9-34.8^oC
2	PH of solution	6.5 to 7.2	6.8-7.0
3	Air Pressure	12 to 18psi	15psi
4	Concentration of sodium chloride	5_+1%	5.0 - 5.2%
5	Collection of solution per hour	1 to 2 ml	1.2 to1.3 ml
6	Test hours	48 hrs	48hrs

Note:Red rust observed at welded area at the end of 24 hrs of testing

Red rust observed at welded area at the end of 48 hrs of testing

The photograph taken is exhibited as below:

Initial Weight	After 24 hrs Weight	After 48hrs Weight
31.8196g	31.8420g	31.8326g

Table 5.2.4:Corrosion Test values of P91 for 48hrs

Material Used:SS304 for 24 hr

Here the metal was exposed to the corrosion test for 24hrs at certain conditions such as chamber temperature ranging from 33-37°C and pH of the solution from 6.5-7.2 and air pressure ranging from 12-18psi and the concentration of sodium chloride of 4-6% and collection of solution per hour is between 1-2ml in this certain conditions the ss304 was investigated and there is a loss of weight

in the material of 0.0020. therefore the corrosional behaviour in the metals is existing.The microstructural images are taken when the corrosion occurred

The corrosion rate occurred is $0.0020/(1)^2=0.0020$

SL.NO	TEST CONDITION	REQUIREMENTS	ACTUAL
1	Chamber Temperature	35_+2^0C	33.9-34.6^oC
2	PH of solution	6.5 to 7.2	-7.0
3	Air Pressure	12 to 18psi	15psi
4	Concentration of sodium chloride	5_+1%	5.0 - 5.2%
5	Collection of solution per hour	1 to 2 ml	1.2 ml
6	Test hours	24 hrs	24hrs

Note:Red rust observed at welded area at the end of 24 hrs of testing

The photograph taken is exhibited as below

Sample	
Initial Weight	Final Weight
9.0521g	9.0501g

Table:5.2.5:Corrosion Test values of SS304 for 24hrs

Material Used:SS304 for 48 hrs

Here the metal was exposed to the corrosion test for 24hrs and 48hrs at certain conditions such as chamber temperature ranging from 33-37°C and pH of the solution from 6.5-7.2 and air pressure ranging from 12-18psi and the concentration of sodium chloride of 4-6% and collection of solution per hour is between 1-2ml in this certain conditions the ss304 was investigated and there is a loss of weight

In the material of 0.0026. therefore the corrosional behaviour in the metals is existing. The microstructural images are taken when the corrosion occurred. the difference between 24-48hrs range is considered for the corrosional behaviour of the sample

The corrosion rate occurred is $0.0026/(1)^2=0.0026$

SL.NO	TEST CONDITION	REQUIREMENTS	ACTUAL
1	Chamber Temperature	35_+2^0C	33.9-34.8^oC
2	PH of solution	6.5 to 7.2	6.8-7.0
3	Air Pressure	12 to 18psi	15psi
4	Concentration of sodium chloride	5_+1%	5.0 - 5.2%
5	Collection of solution per hour	1 to 2 ml	1.2 to1.3 ml
6	Test hours	48 hrs	48hrs

Note:Red rust observed at welded area at the end of 24 hrs of testing

Red rust observed at welded area at the end of 48 hrs of testing

The photograph taken is exhibited as below:

Initial Weight	After 24 hrs Weight	After 48hrs Weight
9.3207g	9.3197g	9.3171g

Table 5.2.6: Corrosion Test values of SS304 for 48hrs

5.3 MICROSTRUCTURE ANALYSIS

Microstructure is the tiny scope design of a material, characterized as the construction of a pre-arranged surface of material as uncovered by an optical magnifying lens above 25* amplification. The microstructure of a material (like metals, polymers, pottery or composites) can emphatically impact actual properties like strength, sturdiness, flexibility, hardness, consumption opposition, high/low temperature conduct or wear obstruction. These properties thus oversee the use of these materials. in modern practice.

5.3.1.MICROSTRUCTURE GENERATION:

Computer-simulated microstructures are produced to duplicate the microstructural highlights of genuine microstructures. Such microstructures are alluded to as engineered microstructures Synthetic microstructures are utilized to research what microstructural include is significant for a given property To guarantee measurable, the idea of microstructure is perceptible in macrostructural highlights in ordinary articles. Stirred steel, for example, the packaging of a light post or street divider, shows a non-consistently hued interwoven of interlocking polygons of various shades of dark or silver. Every polygon is a solitary gem of zinc sticking to the outer layer of the steel underneath. Zinc and lead are two normal metals which structure huge precious stones (grains) noticeable to the unaided eye. The molecules in each grain are coordinated into

one of seven 3d stacking plans or precious stone grids (cubic, tetrahedral, hexagonal, monoclinic, triclinic, rhombohedral and orthorhombic). The bearing of arrangement of the frameworks vary between adjoining precious stones, prompting difference in the reflectivity of each introduced face of the interlocked grains on the electrified surface. The normal grain size can be constrained by handling conditions and organization, and most compounds comprise of a lot more modest grains not apparent to the unaided eye. This is to expand the strength of the material (see Hall-Petch Strengthening).

5.3.2.MICROSTRUCTURE CHARACTERIZATIONS:

To evaluate microstructural highlights, both morphological also, material property should be described. Picture handling is a strong procedure for assurance of morphological elements, for example, volume portion, incorporation morphology, void and grain directions. To obtain micrographs, optical as well as electron microscopy are usually utilized. To decide material property, Nanoindentation is a vigorous method for assurance of properties in micron and submicron level for which customary testing are not achievable. Traditional mechanical testing like malleable testing or dynamic mechanical examination (DMA) can return perceptible properties with practically no sign of microstructural properties. Nonetheless, can be utilized to create various other stochastic models Nanoindentation can be utilized for assurance of neighborhood microstructural properties of homogeneous too as heterogeneous materials. Microstructures can likewise be portrayed utilizing high-request measurable models through which a bunch of confounded factual properties are extricated from the pictures. Then, these properties equality among produced and genuine microstructures, microstructures are adjusted after age to match the measurements of a genuine microstructure. Such strategy empowers age of hypothetically limitless number of PC reproduced microstructures that are genuinely something very similar (have similar measurements) however stochastically unique (have different arrangements).

EQUIPMENT USED: Metallurgical Microscope Dewriter Tech

OBSERVATION: Etchant Used : Vilella's Reagent

Material Used: P91

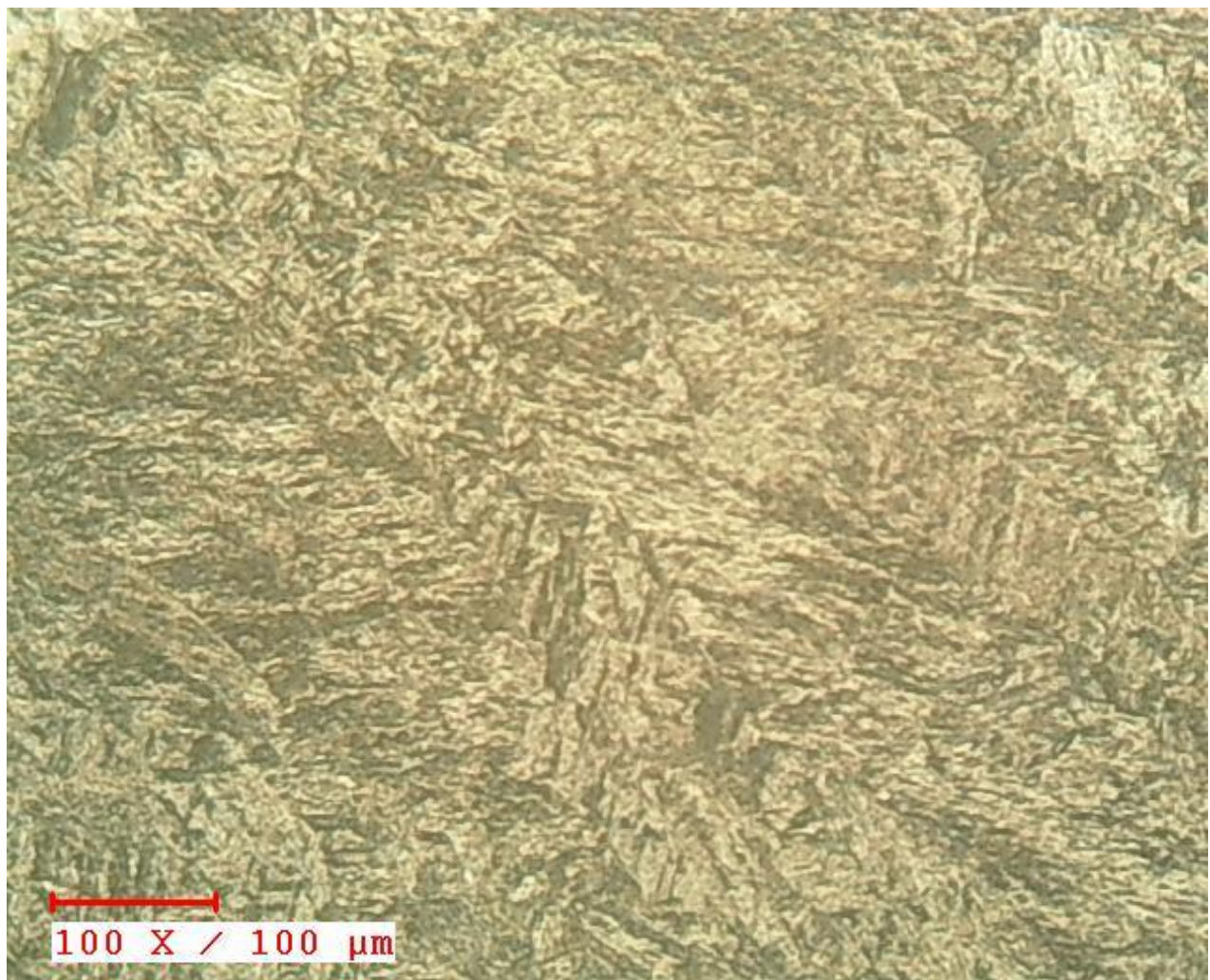


Fig.5.3.1. Microstructural image of P91 at 100x



Fig.5.3.2. Microstructural Image of P91 at 200x

The microstructure shows tempered martensite in weld metal

EQUIPMENT USED:Metallurgical Microscope Dewriter Tech

OBSERVATION:Etchant Used :Glyceregia

Material Used:SS304

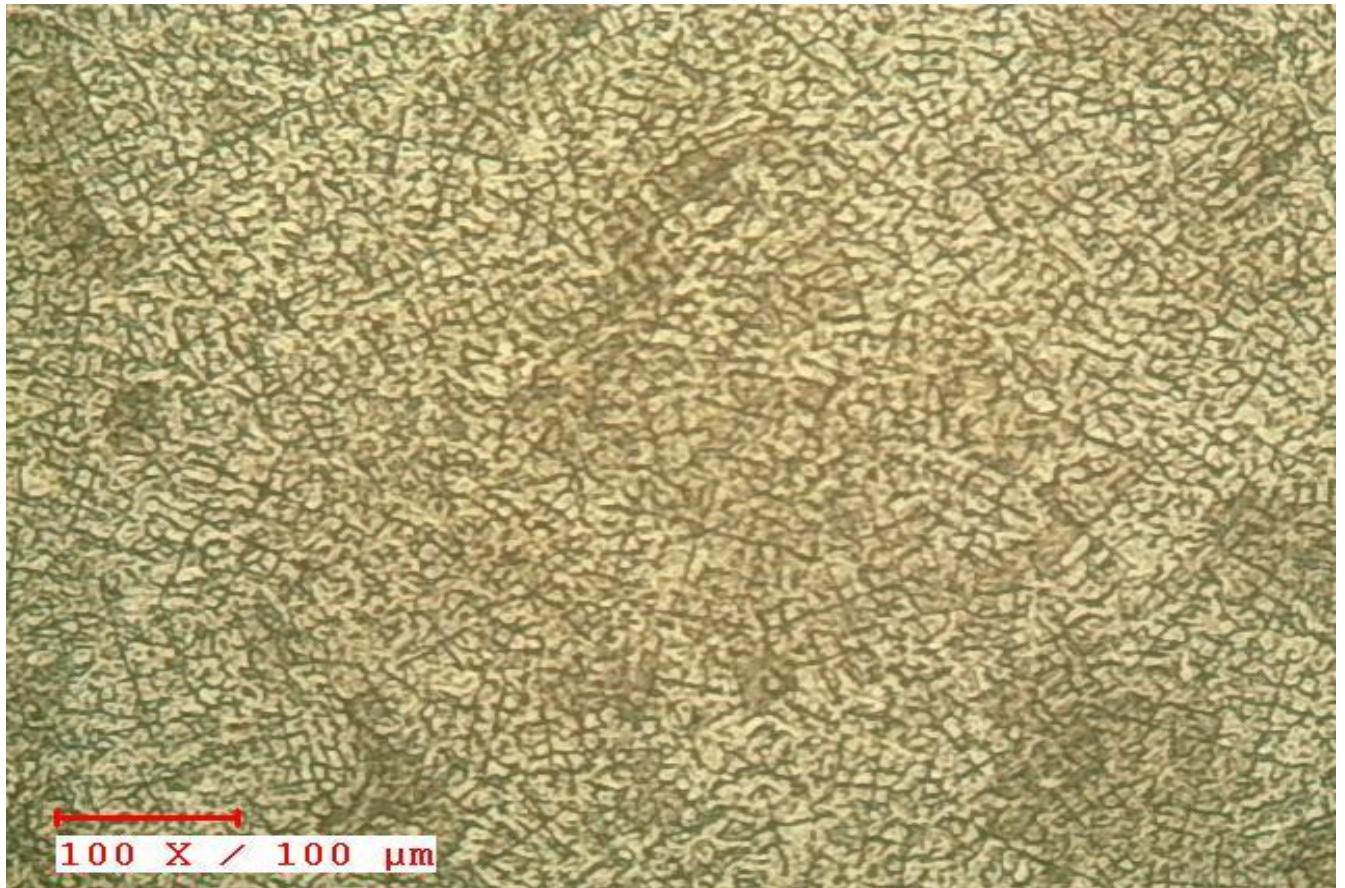


Fig.5.3.3. Microstructural Image of SS304 at 100x

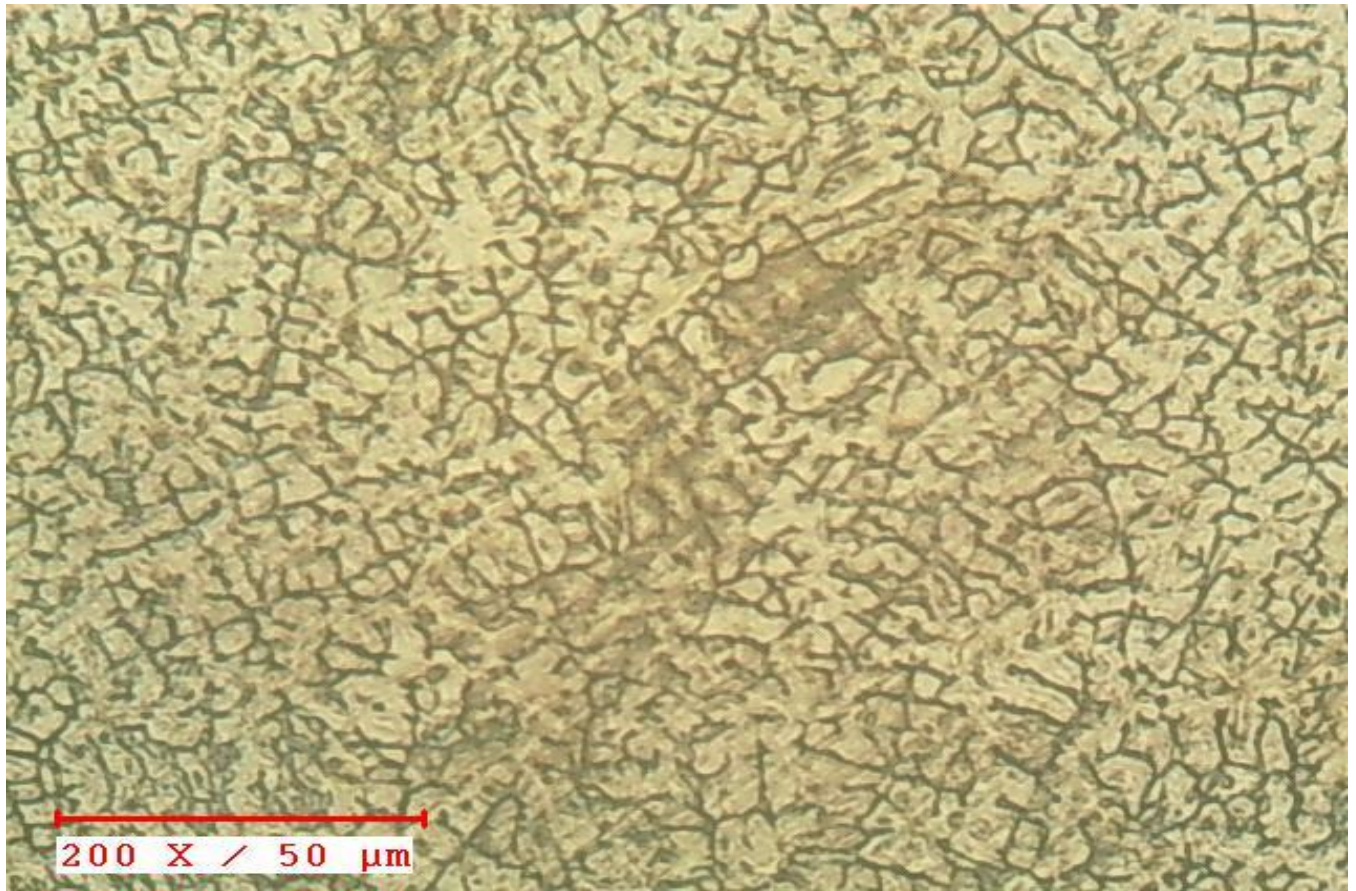


Fig.5.3.4. Microstructural Image of SS304 at 200x

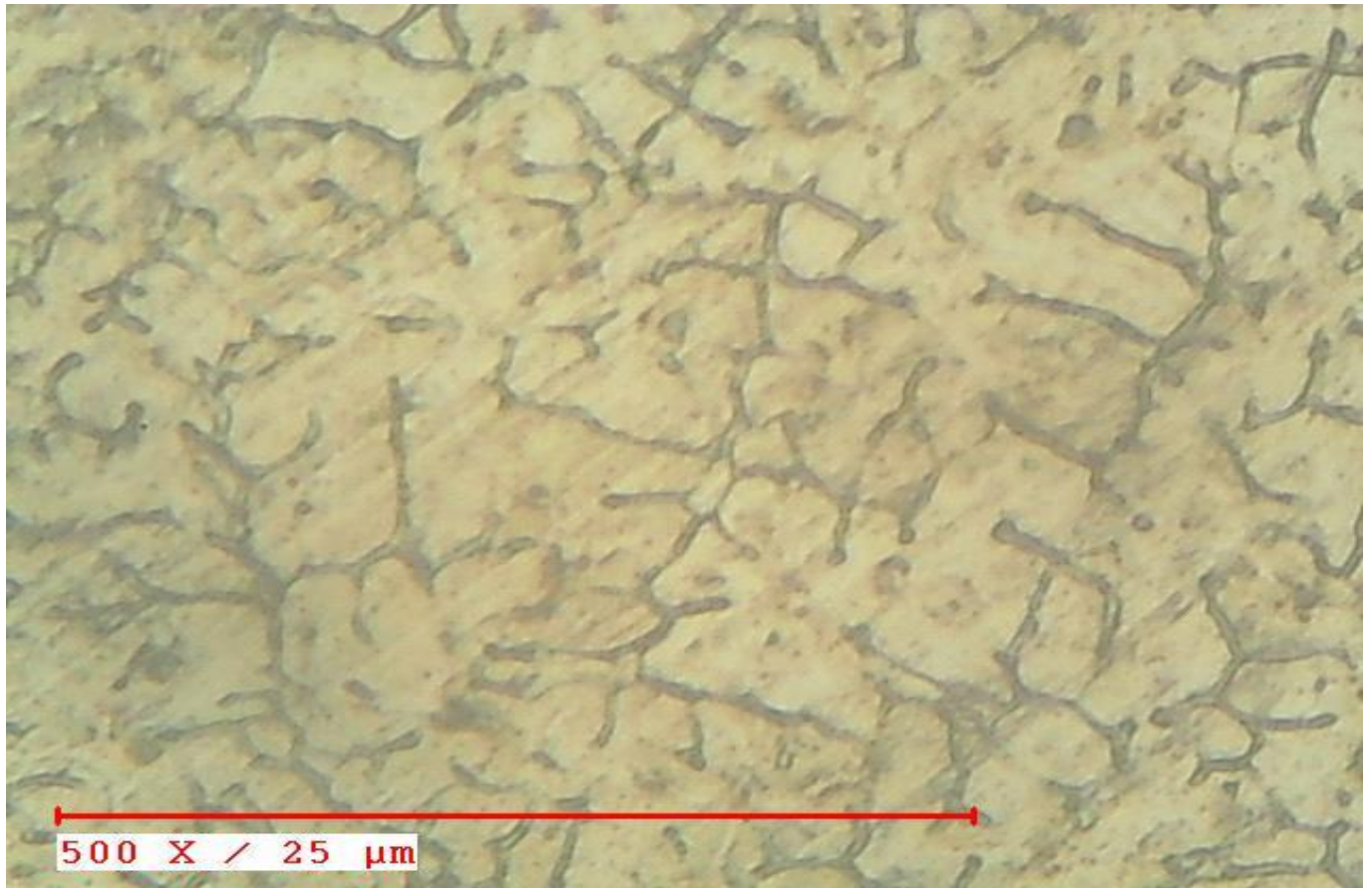


Fig 5.3.5 Microstructural Image of SS304 at 500x

The microstructure shows interdendritic structure in weld metal.

CHAPTER-6

6.1 CONCLUSION

The mechanical and corrosional behaviour of the materials by the Vickers hardness testing and salt spray corrosional testing and microstructural images of the corroded samples the results were as follows

6.1.1.CORROSION

The corrosional test was done for two range time periods the corrosional rate is increasing in rapid rapid way and the losing the weight of the metal . The readings are shown in the observation section and the microstructural images are provided for the better reference of the corrosion

6.1.2.HARDNESS

SS304:

The hardness test was done at two points of the metal at HAZ zone and welded zone . The readings were satisfactory and the penetration depth is more at the welded area and the hardness is also high at the welded area

P91:

The vicker's hardness test was done at two points of the metal at HAZ zone and welded zone . The readings are satisfactory. The hardness at the welded area is more than the HAZ zone . The penetration depth is also high at the welded area because of the extra layering of the weld.

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