JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

SIGNIFICANCE OF HAZ ON THE PERFORMANCE OF WELD JOINTS

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Abstract: ***To assure the quality of fabrication and in the fabrication sector, welding is crucial. Early diagnosis and rectification of welding faults are crucial to ensuring that welds can perform their intended function, as they can significantly impact weld lifespan and performance. The term "heat-affected zone," or HAZ, is important when discussing weld joints. The region surrounding the weld where the heat from the welding alters the characteristics of the metal is known as the heat-affected zone (HAZ).***

The strength of the joint may be affected. High-quality welds depend on your ability to comprehend and manage the HAZ. A major factor influencing the performance of weld joints is the heat-affected zone (HAZ). The heat generated during welding has an impact on nearby metal. In the present work, ER 70S G and ER 316L Filler Rods are used to join MS Flat and SS Flat. Welding Current, Voltage, Torch Angle, Welding Speed, Flow Rate of Inert Gas, and Filler Rod diameter are considered welding input parameters, and Tensile Strength, Hardness, and Impact Strength are considered output responses.

Keywords: Stainless Steel and Mild Steel, Tensile Properties, Hardness.

LITERATURE REVIEW

Naitik Patel et al. [1] carried out the features highlighting the TIG as a better prospect for welding than other processes, especially for joining two dissimilar-metal with heating thermal or applying the pressure or using the filler material for increasing productivity with less time and cost constrain. They attempted to understand the effect of TIG welding parameters welding current, gas flow rate, and welding speed, which are influences on responsive 23 output parameters such as hardness of welding, and tensile strength of welding, by using optimization philosophy. Ravinder & S.K. Jarial [2] studied the parametric optimization of TIG welding on stainless steel [202] and mild steel by using the Taguchi method and found the controcold-rolledich had varying effects on the tensile strength, and voltage had the highest effect and also found the optimum parameter for tensile strength current 80A. Arc voltage 30V.

Dr. Simhachalam et al. [3] carried on the effect of welding process parameters on the mechanical properties of stainless steel -316 [18Cr-8N] welded by TIG welding. The specimen size is 40x15x15mm for experimentation observed that the welding current has a significant effect though the filler rod does have some effect similar to the current but compared to the current it is less significant. MINITAB software is used for the prediction of the hardness, impact strength, and depth of penetrations.

Javed Kazi et al. [4] presented a review of various welding techniques in the International Journal of Modern Engineering Research Publications in 2015. Their prime focus is on the fulfillment of objectives of industrial application of welding by producing better quality products at minimum cost and increasing productivity. An attempt is made to understand various welding techniques and to find the best welding technique for steel. Special focuses have been put on TIG welding. For this study, they analyzed strength hardness, modulus of rigidity, ductility, breaking point, % elongation, etc. at constant voltage on hardness testing machine and UTM. Sanjeev Gupta 2016 [5] Experimented to optimizer the condition for performing the welding on an Ultra-90 specimen in which he varied the current and voltage while keeping the gas flow rate constant and observed that the welding joint was not made properly below 50A and 200A since then burning of specimen stated. Leroy Gardner [6] comprising tensile test on flat and corner materials. Initial geometric imperfections were generally low in both the hot-rolled and cold-rolled steel sections, with large imperfections emerging towards the ends of the cold-formed members. The current codified slenderness limit was evaluated based on compressive and bending tests on hot-rolled and cold-rolled sections.

Jaile mill (2004) [7] self-drilling screw joint for cold rolled steel channel portal. The conclusion of earlier testing by the first author that widely used bolted and plate moments connection is not suitable. They knew the joint of portal frames constructed from thin cold cold-formed channel sections. The order traditionally used joint configuration of a mitered joint with two bolts is the end plates may need to be sized conservatively.

Shah Foram Ashok bhai [8] steel consumption is higher in industrial shed structures using hot-willed steel and cold-rolled steel sheets as compared to industrial shed structures using cold-formed steel sections. The weight is higher in industrial sheds which use hot rolled sheets. The weight of an industrial shed with cold-formed sections is reduced by 32.03% than an industrial shed structure with hot-rolled sheets. An attempt is being carried out for the comparison between hot-rolled and cold-milled steel.

J. O. Olawale et al [09] studied process variables of shielded metal-arc welding (SMAW) and post-weld heat treatment on some mechanical properties of lowcarbon steel weld. Three hundred and sixty pieces of weld samples were prepared. The samples were welded together using AWS E6013 electrodes with a DC arc welding process.

Ruangyot Wichienrak & Somchai puajindanetr [10] cold rolled steel industry in type of batch sealing furnace, the mechanical properties of steel sheet have variation by each position. The meters of annealing temperature and time were analyzed to work out the source of mechanical properties variation. The mechanical properties which were examined i.e. Yield strength, tensile length, 4 elongation, and hardness. Increasing the annealing temperature 24 remarkably caused the yield strength, tensile strength, and hardness, whereas the elongation model 5982. Sachita S.Nawale [11] thin sheet steel products are extensively used in the building industry. These thin steel sections are cold-formed i.e., their manufacturing process involves forming steel sections in a cold state (Le. without application of heat) from steel sheets of uniform thickness. The thickness of the cold rolled sheets is usually 1 to 3mm. The method of manufacturing is important as it differentiates these products from hot-rolled steel sheets. Normally, the yield strength of steel sheets used in cold from sections is at least 280N/mm2, although there is a trend to use steels of high strength, sometimes as low as 230N/mm2.

Chunquan Liu et al [12] study and investigate of mechanical properties of hot-rolled and cold-rolled steel. In experimental steel, processes by quenching and tempering (Q&T) heat treatment. exhibited excellent mechanical properties of hot rolled (strength of 1050-1130 MPa) and cold rolled steel (strength of 878-1373 MPa). The fracture modes of the hot rolled sample. quenched from 650c, and cold rolled sample, quenched from 650e.

Bread Wolter & Gred, Dobmann [13] In the forming of steel by hot rolled and cold rolled steels a broad range of semi-finished and final products can be produced with specific- technological properties. Micro-magnetic techniques, like 3MA have reached a sophisticated level of industrial standard and are ready to be integrated into the production process of steel manufacturers. Mechanical properties, like tensile, yield strength, and hardness as well as residual or structural stress level can be predicted with high accuracy.

Abhimanyu Chauhan [14] performs tungsten inert gas welding on a 5mm thick plate. Without using filler material. the welding is performed by maintaining a completely different gap between the plates to be welded. The tensile strength and weld bead geometry of the weld have been investigated here. It is noted that by maintaining a minimum gap full penetration welding of the plate can be done which gives strength that is almost similar to the base material and maximum depth of penetration was acquired with a parametric combination of maximum current and minimum welding speed. .

Singh et.al 2016 [15] presented a review of the study about the optimal process parameters for TIG welding. The different scientific research in TIG welding to find the best parameter with the help of the Taguchi technique with various process parameters (different gas, electrode diameters, different compositions of filler rods) can be taken for welding 309 stainless to study the effects of parameters on impact strength, tensile strength, hardness of weld joint residual stress heat affected zone of butt weld joint on different grove angles.

Kumar et.al 2015 [16] This paper investigated the performance of stainless steel 304 using the GTAW process by the design of experiment method and optimized by L-18 orthogonal array design matrix was followed. And Taguchi`s method was used to analyze the results. Mechanical testing-Tensile testing, microhardness testing, and microstructures were carried out to check the performance of the welded joints

Ravisankar et.al 2014 [17] in this article describe the temperature distribution and residual stresses for a TIG circumferential butt joint of AISI 304 from experimentation. To achieve proper weld penetration and heat-affected zone an optimum heat input value is chosen. An increase in weld speed and power causes to increase in temperature distribution and longitudinal and circumferential stress.

Patil et al. [18] in their study, worked for experimental investigation for the optimization of process parameters for TIG welding. The study was focused on enhancing welding penetration in activated fluxcoated TIG welding. During the study, they investigated the optimum parameters for enhancing weld penetration for AISI-304 steel plate of dimensions100mm*70mm*5mm.

INTRODUCTION

- **Definition of welding:**

Welding is a fabrication process in which two metals are joined by using high heat to melt and pressure the parts together and allow them to cool, causing fusion.

Advantages of welding:

- Strong and tight joining
- Cost-effectiveness
- Simplicity of welded structures design
- Welding processes may be mechanized and automated

Disadvantages of welding:

- Internal stresses, distortions, and changes of microstructure in the weld region Harmful effects: light, ultraviolet radiation, fumes, high temperature.

Applications of welding:

- Buildings and bridges structures;
- Automotive, ship, and aircraft constructions;
- Pipelines;
- Tanks and vessels;
- Railroads;
- Machinery elements.

Classification of welding:

Gas welding:

- Oxy-acetylene gas welding
- Oxy-gasoline gas welding
- MAPP gas welding
- Butane or propane welding
- Hydrogen gas welding

RESISTANCE WELDING

- Spot resistance welding
- Projection resistance welding
- Seam resistance welding
- Flash resistance welding
- Butt resistance welding
- Upset resistance welding

ARC WELDING

- Shielded metal arc welding
- Flux-cored arc welding
- Submerged arc welding
- Gas metal arc welding
- Welding Gas tungsten arc welding
- Carbon arc welding

THERMIT WELDING

- Fusion welding
- Pressure welding

LASER BEAM

- Fiber Laser Welding
- Laser Spot
- Keyhole Laser Welding
- Laser Seam Welding
- CO2 Laser Welding
- Laser-Hybrid Welding

SOLID-STATE WELDING

- Friction
- Ultrasonic
- Diffusion

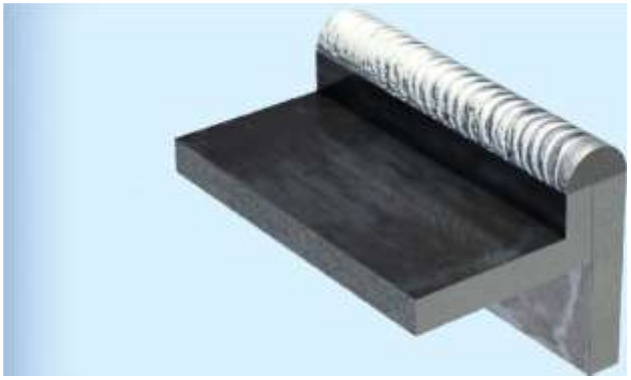
TYPES OF WELD JOINTS

BUTT JOINT

A butt joint or butt weld is a joint where two pieces of metal are placed together in the same plane and the side of each metal is joined by welding.

Fig1.1 Butt Joint

- Square
- Single bevel
- Double bevel
- Single J
- Double J
- Single U
- Double U



- Single V
- Double V

LAP JOINT

Lap welding joints are essentially a modified version of the butt joint. They are formed when two pieces of metal are placed in an overlapping pattern on top of each other.

Fig:1.2 Lap Joint

- Fillet welding
- Spot welding
- Plug welding
- Slot welding
- Bevel groove welding
- Flare bevel groove welding
- J-groove welding

EDGE JOINT

In this, both the metal plate surfaces are placed together, so that they are adjacent and generally parallel in position at the point of welding. It is known as edge joint welding.

- U-groove 16
- V-groove 4
- J-groove
- Corner-flange

- Bevel-groove
- Square-groove

Fig:1.3 Edge Joint

CORNER JOINT

The corner joint welding is used to join two members that are located at an approximately right angle to each other in the form of an "L".

Fig:1.4 Corner Joint

- Fillet weld
- Closed
- Half-open
- Fully open

T-JOINT

A t-joint is formed when the two metal plates are intersected to an angle of 90 degrees with one plate lying on the center of the other plate like a "T" shape.

Fig:1.5 T-Joint

- Fillet welding
- Plug welding
- Slot welding

- Bevel groove welding
- Flare bevel groove welding
- J-groove welding

GAS TUNGSTEN ARC WELDING

Gas tungsten arc welding (GTAW) is an electric arc welding process that uses a non-consumable tungsten electrode to produce the weld. The gas tungsten arc welding is also known as tungsten inert gas (TIG) welding.

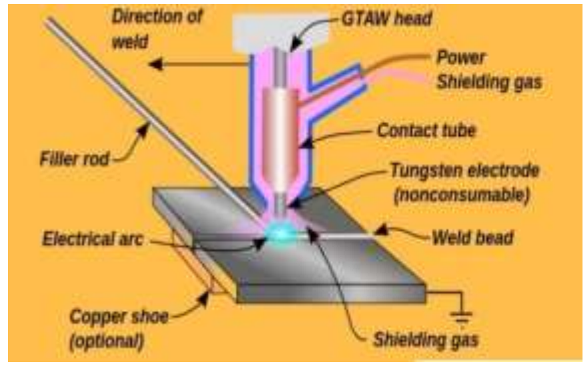
In the case of GTAW, the weld area is protected from atmospheric contamination by a shielding gas. This shielding gas is usually an inert gas such as argon. In general, a filler material is also used, although some welds, known as autogenous welds, do not require it. In this welding process, a constant current welding power supply is used to produce energy which is conducted across the arc through a column of highly ionized gas and metal vapors, known as plasma.

ADVANTAGES OF GAS TUNGSTEN ARC WELDING

- No flux is used in gas tungsten arc welding. Therefore, there is no flux entrapment in the weld bead.
- The welds made with gas tungsten arc welding are stronger and more ductile than those of other metal arc welding processes.
- TIG welds are more corrosion-resistant.
- With the GTAW, a wide variety of joint designs can be used because no flux is required. • The gas tungsten arc welding provides protection to the weld from atmospheric contamination.

DISADVANTAGES OF GAS TUNGSTEN ARC WELDING

- In the case of the TIG welding process, the concentrations of shielding gas may build up.



- It produces brighter ultraviolet rays than other welding processes.
- It has lower filler metal deposition rates.

METHODOLOGY

Tungsten Inert Gas (TIG) welding, also known as Gas Tungsten Arc Welding (GTAW), is a precise and versatile welding process commonly used for joining metals like stainless steel, aluminum, magnesium, and copper alloys. Here's a general methodology for TIG welding:

Preparation:

Ensure you have the necessary safety equipment: a welding helmet with an appropriate shade lens, welding gloves, and protective clothing. Clean the workpiece surfaces thoroughly to remove any contaminants, such as oil, grease, paint, or rust, which can affect weld quality.

Select the appropriate filler metal based on the materials being welded.

Setup:

Choose the correct type and size of tungsten electrode for the job, typically thoriated, created, or lanthanide tungsten electrodes are used.

Grind the tungsten electrode to a point, ensuring it is clean and sharp.

Set up the TIG welding machine according to the material thickness and type, as well as the desired welding current and gas flow rate. Connect the gas supply (usually argon or a mixture of argon and helium) to the welding machine.

Technique:

Position the workpiece and secure it in place using clamps or fixtures.

Position yourself comfortably, ensuring stability and good visibility of the weld area.

Start the welding arc by striking the tungsten electrode against the workpiece and withdrawing it slightly to establish an arc.

Maintain a consistent arc length, typically around 1/8 inch (3.2 mm), by controlling the distance between the tungsten electrode and the workpiece.

Control the heat input by adjusting the welding current and travel speed. Too much heat can lead to excessive penetration and distortion, while too little heat may result in incomplete fusion.

Add filler metal as needed to reinforce the weld joint, controlling the deposition rate and ensuring proper fusion with the base metal.

Move the torch smoothly along the joint, maintaining a steady welding speed and uniform bead appearance. Ensure adequate shielding gas coverage by directing the gas flow over the weld pool to protect it from atmospheric contamination.

Post-Welding:

Allow the welded joint to cool naturally to avoid introducing residual stress or distortion. Inspect the weld for any defects, such as cracks, porosity, or incomplete fusion, and address them as needed.

Clean the weld area to remove any slag, spatter, or residue using a wire brush or appropriate cleaning method. **Practice and Refinement:**

TIG welding requires practice to master, so continue honing your technique through repetition and experimentation.

Seek feedback from experienced welders, and analyze your welds to identify areas for improvement.

Adjust your welding parameters and technique based on the specific requirements of each welding project and the feedback you receive.

EXPERIMENTATION MATERIAL SELECTION

Mild steel plates of sizes 150x100x6 mm3 and Stainless-steel plates of 150x100x6 mm3 were selected as base materials because this material is widely used for engineering applications in the industries. The metal is mostly used for the fabrication work and building of structures. This metal is also widely used in the construction field, automobile field, etc., due to its excellent weldability.

PARAMETERS OF TIG WELDING

CURRENT FOR S-S FILLER: TIG welding must be operated with a constant current power source, either DC or AC. A constant current power source is essential to avoid excessively high currents being drawn when the electrode is short-circuited onto the workpiece surface. The current supply is 150 amps.

CURRENT FOR M-S FILLER: The current for M-S filler is 128 amps on both front & back.

VOLTAGE IN TIG WELDING: The voltage for TIG welding depends on the material being welded and the type of gas used. The voltage is associated with the arc length, so a longer arc will increase the voltage and a shorter arc will decrease it. TIG welders have non-adjustable voltage settings.

ARC LENGTH: In TIG welding, the arc length is the distance between the tungsten electrode and the workpiece. It is an important parameter that affects the quality of the weld. The ideal arc length depends on various factors such as the type of material being welded, the welding current, and the electrode diameter. According to welding experts, the ideal arc length for TIG welding is typically between 1.6 to 3.2 millimeters.

TORCH ANGLE: When TIG welding, the angle between the torch and the base metal is important. You need to angle the torch slightly to see the puddle and provide access to the filler rod. According to a welding expert, Ron Covell, a 15-degree angle is a good starting place, although some welders prefer a bit more or less.

V-GROOVE CUTTING: V groove welding is a popular technique used in the field of welding to join two pieces of metal together. It involves creating a V-

shaped groove on the edges of the metal pieces, which allows for better penetration of the weld. This type of welding is commonly used in applications where a strong and durable joint is required, such as in structural steel fabrication and pipe welding. The V groove provides a larger surface area for the weld, resulting in a stronger bond between the two pieces of metal. It is important to note that the angle and depth of the V groove can vary depending on the thickness and type of metal being welded. Based on the thickness and width of the base plate, the single v groove angle should be between 60 and 70 degrees.

Fig:3.1 V-Groove Cutting

SELECTION OF FILLER MATERIAL

MILD STEEL FILLER ROD

Tungsten Inert Gas (TIG) welding is a process that requires the use of a filler material to join two metals together. The filler material is added to the weld pool to help create a strong bond between the two metals. Mild steel (MS) is a common material used in TIG welding. The most commonly used filler material for MS TIG welding is ER70S-2. This filler material produces welds that are highly ductile with excellent mechanical properties and high levels of corrosion resistance

Fig: 3.2 mild steel filler rod **STAINLESS STEEL FILLER ROD**

Stainless steel (SS) is a popular material used in welding applications. The filler material used in SS welding depends on the type of SS being welded and the desired properties of the weld. The most commonly used filler materials for SS welding are ER308L and ER316L. ER308L produces welds that are highly ductile with excellent mechanical properties and high levels of corrosion resistance.

Fig: 3.3 Stainless steel filler rod

WELDING OPERATION

We prepare two metal pieces to make a single butt joint by using direct current and reverse current with the same type of electrode

POSITIONING AND JOINING

Align your metal to make sure the edges line up well. They should be smooth and align cleanly. Make tack welds. These will hold the metal together and prevent it from warping or bending inward when the weld is finished. To make a tack weld, strike an arc and let it sit for a few seconds This step also includes attaching support to the back face of the metal plates at different spots to provide support as well as useful to hold after welding by using holding devices.

Fig: 3.4 Positioning And Joining

WELDING PROCESS

The shielded Arc Welding (SMAW), this process uses a non-consumable tungsten electrode to produce the weld. The filler material is added manually to the weld pool. TIG welding produces high-quality welds with excellent mechanical properties and high levels of corrosion resistance.

Fig: 3.5 Welding

HARDNESS TEST

Hardness testing measures a material's resistance to permanent deformation at its surface, by pressing a harder material into it. It is used in a number of industries for material comparison and selection, as well as quality control of a manufacturing or hardening process. A specifically manufactured indenter, with chosen dimensions, is used to press into the material being tested, with a prescribed force. The pressing time is also important in the hardness test. Hardness is not a fundamental physical property of a material, but rather a measured characteristic. It can however provide some valuable information about the strength and durability of a material, depending on the application it is intended for.

LEEB HARDNESS TEST

The Leeb hardness testing, otherwise called as Leeb Rebound Hardness Test (LRHT), is considered as one of the four commonly used methods to test the hardness of the metal. It is a type of non-destructive testing used to inspect large-sized workpieces weighing above 1 kg. It also measures the coefficient of restitution. Unlike other stationary traditional methods including Rockwell, Brinell, and Vickers which were implemented only in the laboratories or testing areas, the Leeb method proves to be portable by achieving high testing rates at a reduced cost. The unit of hardness is Hardness Leeb (HL). According to the dynamic Leeb principle, the hardness value is derived from the energy loss of a defined impact body after impacting on a metal sample, similar to 34 the Shore stereoscope. The Leeb quotient (vi, VR) is taken as a measure of the energy loss by plastic deformation: the impact body rebounds faster from harder test samples than it does from softer ones, resulting in a greater value of 1000×vr/vi. A magnetic impact body permits the velocity to be deduced from the voltage induced by the body as it moves through the measuring coil. The quotient 1000×vr/vi is quoted in the Leeb rebound hardness unit HLx (where x indicates the probe and impact body type.

Fig: 3.6 Leeb hardness tester

PENETRATION TEST

Penetration testing is a critical aspect of welding quality control. It is a way to evaluate the quality of a weld and identify any defects that may exist. There are many different types of weld tests, each with its own objective and testing requirements. Tungsten Inert Gas (TIG) welding is a type of welding that uses a non-consumable tungsten electrode to produce the weld. The weld is protected from atmospheric contamination by an inert shielding gas, typically argon2. Penetrant testing (PT) is a non-destructive testing method used to detect surface-breaking defects in materials. In TIG welding, PT is used to detect surface-breaking defects in the weld.

Fig:3.7 Penetration Test consumables

Equipment	Manufacturer	model	Batch no	Date of manufacture	Date of expiry
Penetrant	Oriental chemical Works	115P	P/008/2023	Aug 2023	July2025
developer	Oriental Chemical Works	115 D	D/008 /2023	Aug 2023	July 2025
Penetrant Remover	Oriental Chemical Works	115P R	R/008 /2022	April 2023	March 2024

Table 1: consumables details

CLEAN THE WELD JOINT WITH PENETRANT REMOVER

To clean the weld joint with penetrant remover, you should first remove the excess surface penetrant by wiping the part with a clean, dry towel cloth. Next, you should wipe it with a clean cloth or towel moistened with penetrant remover 1 . Penetrant testing (PT) is a nondestructive testing method used to detect surface-breaking defects in materials. In TIG welding, PT is used to detect surface-breaking defects in the weld

Fig:3.8 Clean the weld joint with penetrant remover

APPLICATION OF PENETRANT

The dye penetrant can be sprayed on the weld pool and wait for some time This time is known as dwell time

PENETRANT REMOVAL

To remove excess penetrant from a weld joint, you should first wipe the part with a clean, dry towel cloth to remove the excess surface penetrant. Next, you should wipe it with a clean cloth or towel moistened with penetrant remover.

Fig:3.9 Penetrant Removal

APPLYING OF DEVELOPER

Applying a developer is the next step after cleaning the weld joint with penetrant remover. The developer is applied to the prepared area by spraying it from a distance of 10 to 12 inches from the surface. After spraying, the developer is left on the surface for a period of 10 to 60 minutes, depending on the material and its service condition. During this time, the developer reacts with the penetrant to form a visible indication of any surface-breaking defects in the weld.

Fig:3.10 Applying Of Developer

RECORDING THE DEFECTS

Recording defects is an essential part of the welding quality control process

Fig:3.11 Recording the defects

TENSILE TEST

The tensile test procedure involves attaching the sample to the testing machine and applying force until the material fractures. The results are typically recorded in a stress-strain diagram. The most important parameters measured in the test are the ultimate tensile strength, yield strength, and elongation at break as shown in Fig 3.11. A tensile specimen of standard dimensions machined from the metal is inserted in a tensile testing machine The machine consists essentially of two parts: the straining or pulling device 8 and an arrangement to measure and register the load on a dial. A gradually increasing tensile load is applied to the specimen and the resultant extension (or strain) of the specimen is observed, The machine consists essentially of two parts: the straining or pulling device and an arrangement to measure and register the load on a dial. A gradually increasing tensile load is applied to the specimen and the resultant extension (or strain) of the specimen is observed

Fig:3.12 Tensile Test

MAGNETIC PARTICLE TESTING

Magnetic particle examination (MT) is a very popular, low-cost method to perform nondestructive examination (NDE) of ferromagnetic material. Ferromagnetic is defined in ASME Section V as “a term applied to materials that can be magnetized or strongly attracted by a magnetic field.” MT is an NDE method that checks for surface discontinuities but can also reveal discontinuities slightly below the surface.

PRINCIPLE OF WORKING

When ferromagnetic material (typically iron or steel) is defect-free, it will transfer lines of magnetic flux (field) through the material without any interruption.

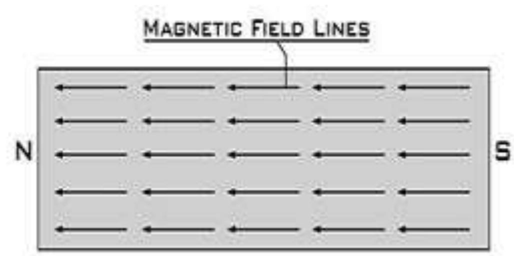


Fig: 3.13 Magnetic field lines

But when a crack or other discontinuity is present, the magnetic flux leaks out of the material. As it leaks, magnetic flux (magnetic field) will collect ferromagnetic particles (iron powder), making the size and shape of the discontinuity easily visible.

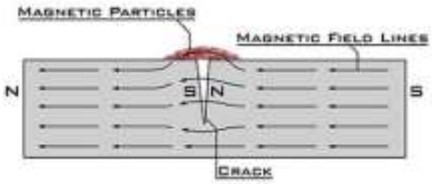


Fig: 3.14 defect detection using magnetic field However, the magnetic flux will only leak out of the material if the discontinuity is generally perpendicular to its flow. If the discontinuity, such as a crack, is parallel to the lines of magnetic flux, there will be no leakage and therefore no indication observed. To resolve this issue, each area needs to be examined twice. The second examination needs to be perpendicular to the first so discontinuities in any direction are detected. The examiner must Ensure that enough overlap of areas of magnetic flux is maintained throughout the examination process so discontinuities are not missed.

MAGNETIC PARTICLE TEST CONSUMABLES

Consumable	**Cleaner**	**Contrast paint**	**Powder**
MANUFACTURER	THE ORIENTAL CHEMICAL WORKS (P) LTD	PRADEEP CHEMICALS	PRADEEP CHEMICALS
MODEL	ORION 115P	WP005	MP005
BATCH NO	P/008/2023	WP/F2900/23	MP/F2900/23
DATE OF MANUFACTURING	AUG 2023	FEB 2023	FEB 2023
DATE OF EXPIRE	JULY 2025	FEB 2026	FEB 2026

PROCEDURE

- Preclean the joint with remover cleaner to ensure the joint is free from slag or rust • Apply white contrast paint on the weld area so that the magnetic powder will be enhanced
- Magnetize the joint using a paramagnet yoke while dusting magnetic powder on the weld
- Magnetic powder accumulates over flaws or imperfections • Record and inspect the joints
- Post-clean the joint

Fig: 3.15 MPT test consumables

- Record the defects where the magnetic particles or magnetic powder accumulate.
- Test may result in getting the lack of fusion, cracks, cold lap, etc…

RESULTS AND DISCUSSION HARDNESS

TEST

The hardness Test is carried out using the Leeb hardness tester.

HARDNESS TEST RESULT FOR STAINLESS STEEL FILLER ROD WHILE JOINING MS FLAT & SS FLAT: TABLE -3 HARDNESS TEST RESULTS

S.NO	MS BASE METAL	HEATAFFECTED ZONE OF METAL	WELD ZONE	HEATAFFECTED ZONE OF METAL	SS BASE METAL
1	272 HL	284 HL	202 HL	474 HL	360 HL
2	255 HL	319 HL	382 HL	481 HL	319 HL
3	266 HL	237 HL	283 HL	376 HL	235 HL

Fig: 4.1 hardness test for ss filler rod weld

HARDNESS TEST RESULT FOR MILD STEEL FILLER ROD WHILE JOINING MS FLAT & SS FLAT

TABLE 4: HARDNESS TEST RESULTS

S.NO	MS BASE METAL	HEATAFFECTED ZONE OF MS METAL	WELD ZONE	HEATAFFECTED ZONE OF SS METAL	SS BASE METAL
1	269 HL	295 HL	343 HL	399 HL	359 HL
2	304 HL	347 HL	440 HL	444 HL	371 HL
3	327 HL	243 HL	311 HL	424 HL	295 HL

Fig:4.2 Hardness test for ms filler rod welding

PENETRATION TESTING

In the penetration test, the weld material is applied with the penetrants which expose the internal defects in the weld joint.

DEFECT OCCURRED WHILE USING SS FILLER ROD FOR WELD JOINT

TABLE 5

S.NO	END TYPE	DEFECTS
1	CAP	UNDERCUT, POROSITY
2	ROOT	LACK OF PENETRATION, EXCESS PENETRATION, MISMATCH

FIG:4.3 defect occurred for stainless steel

DEFECT OCCURRED WHILE USING MS FILLER ROD FOR WELD JOINT
TABLE 6

S.NO	END TYPE	DEFECTS
1	CAP	UNDERCUT, UNDERFILL
2	ROOT	EXCESS PENETRATION

FIG:4.4 defect occurred for mild steel

TENSILE TEST

A Tensile Test is carried out on a Universal Testing Machine to find out the tensile strength, elastic module strain, and Poisson's ratio and deflection after the tensile load is applied

TENSILE TEST WHILE USING SS FILLER ROD

Guage length = 190 mm

Width = 25 mm

Thickness = 6 mm

LOAD AND ELONGATION OF THE SPECIMEN

TABLE 7

S.NO	LOAD	ELONGATION LENGTH	DEFLECTION
1	105 KN	200 mm	25 mm

Fig:4.5 After Elongation

Fig: 4.7 test result for ss filler rod

TENSILE TEST WHILE USING MS FILLER ROD

Width = 25 mm

Thickness = 6 mm

Guage length = 190 mm

Load and Elongation of the Specimen Table 8 :

S.NO	LOAD	ELONGATION LENGTH	DEFLECTION
1	109KN	196mm	18 mm

Fig: 4.6 after elongation

Fig: 4.8 Test results for MS filler rod

MAGNETIC PARTICLE TEST RESULTS

The main defect that is found during this test is a lack of fusion or non fusion lines in both the cases of filler rod

CONCLUSION

After testing the weld joints by using the Dye Penetration Test the following are the defects that occurred while using SS filler rod undercut, porosity, lack of penetration, mismatch, and excess penetration. The defects that occurred while using MS filler rods are lack of penetration undercut, underfill, and excess penetration.

The output of the hardness test for mild steel filler rod while joining MS flat and SS flat is better than the output of the hardness test for stainless steel filler rod while joining MS flat and SS flat is 290HRB (Rockwell Hardness Scale). Hence, the better one is the hardness test for stainless steel filler rods while joining MS flat and SS flat.

The defects in the case of the magnetic particle test are almost the same in the case of both the filler rods, that is the test results show defects look like cracks which is a Non fusion line. During the tensile test, the specimen with mild steel filler rod fails at the parent material which is near the mild steel plate under the load of 109 KN, whereas the specimen with stainless filler rod fails exactly at the weld joint under the load of 105 KN. Mild steel has more thermal diffusivity than stainless steel which can cause damage to metal plates by more discharge of temperature during welding. Hence the weld with stainless steel filler rod is more reliable compared with the weld with mild steel.

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