EXPERIMENTAL ANALYSIS OFWELDED (SMAW) IS 2062 MILD STEEL MATERIAL BY NON DESTRECTIVE TESTING

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ABSTRACT: **-** Shielded Metal Arc Welding (SMAW) is a popular metal fabrication process in construction, shipbuilding operations and metal structure industries. Improving the weld quality is of prime concern. First we are going to do weld without using standard welding procedure specifications (such as Welding speed, Arc voltage &Welding Current using approximate etc..,).Later by using standard Welding Procedure Specifications (WPS) (as per standards like i.e. ASME SEC IX, AWS D1.1 etc…,). We can find the defects by using Non Destructive Testing (NDT) methods such as Radiographic Testing (RT), Penetrant Testing (PT), Ultrasonic Testing (UT) & Magnetic Particle Testing (MPT) for both welding specifications. We improve the quality of welding by reducing defects with standard welding procedures.

Keywords: **-** SMAW, WPS, NDT, RT, PT, UT, MPT & IS – 2062 MILD STEEL.

I. INTRODUCTION

1.1 Welding

Welding is a permanent metal joining process in which two or more parts are joined permanently at their touching surfaces by a suitable application of heat and/or pressure. Often a filler material is added to facilitate coalescence. The assembled parts that are joined by welding are called a weld metal. Welding is primarily used in metal parts and their alloys.

1.2 Non-destructive Testing

Non-destructive testing is the process of determining the defects of the metals, structures, surfaces etc., without causing any sort of damage to the component physically. This is used to detect the dislocations on mental plates, pipes, cylinders, containers, tanks, & welded joints.

II. LITERATURE REVIEW

Shielded metal arc welding (SMAW) method is one in all the foremost ordinarily used material change of integrity processes utilised within the numerous industrial sectors like marine, ship-building, automotive, aerospace, construction and petrochemicals etc. The SMAW method incorporates many varieties of inputs and output streams. The study reviews SMA method with reference to the triple bottom line (economic, environmental and social) property approach. Finally, the study completes recommendations towards achieving economical and property SMAW welding method.

III. EXPERIMENTAL MATERIALS

3.1 IS2062 MILD STEEL

IS2062 may be a product normal of Bureau of Indian Standards. It specifies standards for decent Rolled Medium and High Tensile steel. IS 2062 steels square measure in the main used for structural purpose.

Table 3.1 Chemical Composition % of IS 2062 mild steel

Materials	Percentage
Carbon	0.23
Manganese	1.50
Silicon	0.40
Phosphorus	0.050
Sulphur	0.045

Table 3.2 Mechanical Properties of IS 2062

Grade	Thickness(mm)	Min Yield	Tensile	Elongation
IS 2062	＜20mm	Min 250Mpa	410Mpa	23%
	20mm-40mm	Min 240Mpa	410Mpa	23%
	＞40mm	Min 230Mpa	410Mpa	23%

3.2 E6013 ELECTRODE METAL

E6013 electrodes also contain a large percentage of titanium dioxide in their coating. A wonderfully chosen electrode, which is matched properly, offers the effectiveness & Strength of the attachment.

Fig 3.1 Electrode Metal

Table 3.3 Chemical Composition Electrode

Materials	Percentage
Carbon	0.08
Manganese	0.45
Silicon	0.18
Phosphorus	0.012
Sulphur	0.009

Table 3.4 Mechanical Properties

Name of Property	Load
Tensile Strength	68,200 PSI
Yield Strength	59,500 PSI
Elongation	28%

IV. WELDING PROCEDURE

4.1 SMAW WELDING PROCEDURE

Shielded Metal Arc welding (SMAW) is often remarked as stick or coated electrode welding. Stick welding is among the wide used welding processes.

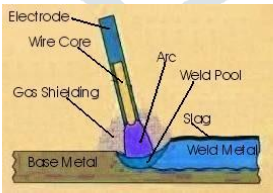


Fig4.1 SMAW welding Process

The flux coating on the conductor melts and forms because the shielding surroundings to avoid the contamination of the liquid weld metal from region gases. The protection is provided by scum fashioned over the surface of pool/metal.

4.2 DEFECTS OF WELDING

4.2.1 Porosity

Porosity is weld metal contamination in the form of a trapped gas. The main cause of porosity is inadequate gas flow, Excessive shielding gas flow or an excess wind in welding area. And can be overcome by using high activity flux, open work space, and by using electrode with adequate deoxidises.

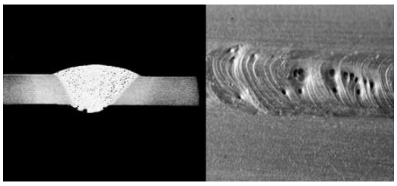


Fig 4.2 Indication of Porosity

4.2.2Cracks

Cracks will occur almost every place within the weld suffering from the extreme heat of welding and may be reduced by providing cooling once welding, use correct joint design using proper welding speed and electrical phenomenon current.

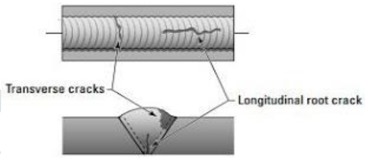


Fig 4.3 Indication of Cracks

4.2.3 Lack of Fusion

Lack of fusion, also called cold lapping or cold shuts, occurs when there is no fusion between the weld metal and the surfaces of the base plate. The most common cause of lack of fusion is a poor welding technique. Can be decreased by using correct electrode diameter and angle reduce deposition rate, cleaning the metal before beginning of the weld.

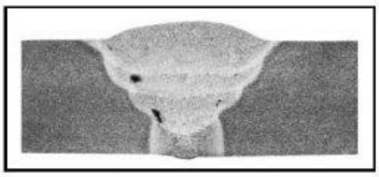


Fig 4.4 Indication of Lack Of Fusion

V. NON-DESTRUCTIVE TESTING

Non-destructive testing (NDT) is the process of inspecting, testing, or evaluating materials, components or assemblies for discontinuities, or differences in characteristics without destroying the serviceability of the part or system. In other words, when the inspection or test is completed the part can still be used.

5.1 RADIOGRAPHIC TESTING

In general, RT is method of inspecting materials for hidden flaws by differential absorption of hard penetrating rays by x- rays or gamma (χ) rays .The intensity of the radiation that penetrates and passes through the material is either captured by a radiation sensitive film (*Film Radiography*). We can get the recorded results.

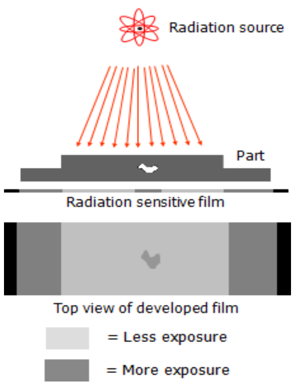


Fig 5.1 Radiographic Testing

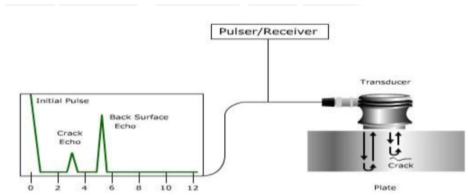
5.2 LIQUID PENETRANT TESTING

The technique is worked out by applying the penetrant on the clean surface and leveyed the penetrent to satisfy the capilary force After a period of time called the “dwell time”, excess surface penetrant is removed and a developer applied and by reverse cappilary fore we observe the imperfections.

Fig 5.2 Visible Of Cracks

5.3 ULTRASONIC TESTING

Ultrasonic testing (UT) works with the main principle of acoustic impendence mismatch i.e. very short ultrasonic pulse waves with frequency 0.1- 15 MHz is transmitted into the materials to know the internal flaws.It is sensitive to both surface and sub-surface discontinuities.



.**Fig5.3 Basic principle of ultrasonic testing**

5.4 MAGNETIC PARTICLE TESTING

In Magnetic particle testing the basic principle is magnetic flux leakage by using mgnetic field and small magnetic particles like iron filings to detect cracks in the component.here we can get high sensitivity,and can have a visual representation of flaws.

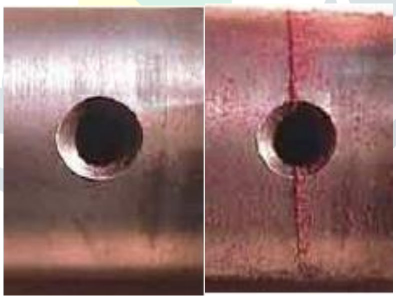


Fig5.4 workpiece performing magnetic particle testing

VI. EXPERIMENTAL PROCEDURES

6.1 WELDING PARAMETERS

After having selected the process of welding, operating conditions must be chosen. The four important parameters are the welding current, wire electrode extension, welding voltage and arc travel speed. These parameters will affect the weld characteristics to a great extent.

6.1.1 Welding the Mild Steel Plate with Existing Parameters

In this process the position over the root, pass and final is chosen all uphill the electrode metal is of E6013 with size 3.15. The direction is of DCSP (Direct Current Straight Polarity) as electrode acts as negative terminal. Therefore, electrons emit from the electrode and flow towards the base plate. It is considered that about 2/3rd of total arc heat (i.e., around 66%) is generated on base plate; whereas, rest of the heat is generated near electrode.

Table6.1: ***Existing Parameters for welding***

RUN NO.	WELDING PROCESS	WELDING POSITION / DIRECTION	ELECTRODE(S)			AMPS	VOLTS	TRAVEL SPEED mm/min
			SIZE	FILLER	POLARITY			
ROOT	SMAW	ALL UPHILL	3.15	E 6013	DCSP	90-120	25-30	90-120
PASS	SMAW	ALL UPHILL	3.15	E 6013	DCSP	120-150	30 – 38	90 – 1209
FINAL	SMAW	ALL UPHILL	3.15	E 6013	DCSP	120-150	35– 40	100 – 150

6.1.2 Welding the Mild Steel Plate with a AWS parameters

In this process also the position over the root, pass and final is chosen all uphill the electrode metal is of E6013 with size 3.15 but the direction is of DCRP (Direct Current Reverse Polarity) as electrode is positive terminal. Therefore, electrons emit from base plate and flow towards the electrode. It is considered that about 2/3rd of total arc heat (i.e., around 66%) is generated at the electrode tip; whereas, rest of the heat is generated near base plate.

Table 6.2: ***AWS Parameters for welding***

RUN No.	WELDING PROCESS	WELDING POSITION/ DIRECTION	ELECTRODE(S)			AMPS	VOLTS	TRAVEL SPEED mm/min
			SIZE	FILLER	POLARITY			
ROOT	SMAW	ALL UPHILL	3.15	E 6013	DCRP	150 - 180	28 – 35	80 – 120
PASS	SMAW	ALL UPHILL	3.15	E 6013	DCRP	180 – 200	30 – 40	90 – 150
FINAL	SMAW	ALLUPHILL	3.15	E 6013	DCRP	180 -200	30 – 40	100 – 150

6.2 RADIOGRAPHY TESTING PROCEDURE

The surface is made clear i.e. removing particle of the materials welded patters, which may cause a sort of imperfections in the film .In this we use the x –ray as the source with 170KV 3MA and for the recording purpose we use AGDF D7 type film, which is covered by a screen for protection to the film with dimensions of 0.10 mm at front, 0.15 mm at back, the penetrometer preferred is DIN type: 10FEEN.

The technique used for the present radiographic testing is single wall single image technique and the exposure time for the experiment is 2 mints.

6.2.1 The Stages in the Production of the Radiograph

For processing of film we have to undergo the steps given below

1. **Exposure** - Latent image created.
2. **Development** - Converts latent image to black metallic silver.
3. **Wash** [stop bath] - Removes excess developer.
4. **Fixing** and Hardening - Dissolves out unexposed silver halide crystals.
5. **Washing** - Removes products of processing.
6. **Dry** - Removes water.

6.3 LIQUID PENETRATING TESTING PROCEDURE

Step 1 Surface Cleaning process

On removal of any rust, scale, welding flux, spatter, and in general, inorganic soils, the surfaces to be inspected shall be cleaned, with solvent cleaner and then finally with a dry lint free cloth.

Step 2 Applying of penetrant

After the area has been cleaned, dried and the temperature of the surface and penetrant are within the range of 40° F (5° C) to 125° F (52° C), the penetrant shall be sprayed directly to the surface to be inspected by means of aerosol container, so that the entire area under inspection is completely covered.

Step 3 Excess Penetrant removals

After the specified dwell time has been elapsed, any penetrant remaining on the surface shall be removed with a dry or slightly moistened cloth of solvent cleaner, taking care to minimize removal of penetrant from possible discontinuity.

Step 4 Drying after removal of excess penetrant

The drying process shall be accomplished by normal evaporation. Drying time shall only be that necessary to adequately dry the part.

Step 5 Application of the developer

Apply the non-aqueous wet developer directly to the area being inspected, by spraying from the aerosol container. Developing dwell time shall not be less than 10 min

Step 6 Examinations and Evaluation of indications

Inspection shall be carried out after the applicable developer dwell time to allow for bleed out of penetrant from discontinuities into the developer coating. All indications shall be evaluated in accordance with the referencing code or Specification.

6.4 ULTRASONIC TESTING PROCEDURE

An ultrasound probe connected to an ultrasonic testing machine transmits high frequency sound waves from the outer surface and from the inner surface, back to the probe .when there is any defect in the part get reflected back area of defect The reflected wave signal is transformed into an electrical signal by the probe and is displayed on a screen.

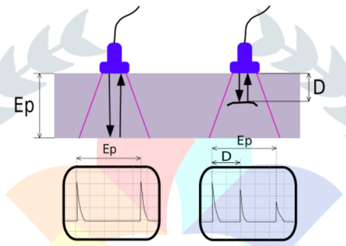


Fig 6.4: ***Observation of Ultrasonic Testing***

1) Left: A probe sends a sound wave into a test material. There are two indications, one from the initial pulse of the probe, and the second due to the back wall echo.

2) Right: A defect creates a third indication and simultaneously reduces the amplitude of the back wall indication.

Fig 6.5: ***Experimental setup***

6.5 MAGNETIC PARTICLE TESTING PROCEDURE

The following stages are necessary to ensure satisfactory detection of defects

Step 1 Surface Preparation of Component before Testing

Removal of loose rust and scale is to be done to prevention of ink from contamination. In case of painted parts the paint should be degreased to highlight the contrast of defect indications

Step 2 Initial Demagnetization

As the part may undergo the machining process there may be partial magnetic field, this kind of residual magnetism should be removed.

Step 3 Magnetization of the Component

We have different technique in the magnetic particle testing for producing of the magnetic field among them we have chosen the yolk method

Step 4 Applying of Magnetic Particles

The magnetic flux particles are sprayed on the surface of the metal where the inspection is performed they may be in different forms like wet method & dry method. In the wet method, particle use a liquid medium and in dry method, particles are carried by air.

Step 5 Viewing

The black or red paste or powder indications are viewed under proper illumination.

Step 6 Marking of Defects

All relevant indication should be marked. For permanent record, apart from television recording and photography, the area under inspection can be covered with a transparent adhesive film.

Step 7 Demagnetization

The demagnetization should be done once after the marking of the defects are done this can be done by changing the current flow.

VII. RESULT ANALYSIS

Finally after performing the process of shielded metal arc welding (SMAW) with existing and AWS parameters on the specimen of IS 2062 mild steel material and find the defects by using non-destructive testing (NDT) namely

1) Radiographic Testing
2) Penetrant Testing
3) Ultrasonic Testing
4) Magnetic Particle Testing

We get the following results

7.1 TEST REPORT OF MILD STEEL PLATE WELDED WITH EXISTING PARAMETERS

Here we are going to discuss various NDT results which have been tested on the plate welded with existing parameters.

7.1.1 Radiographic testing results

By the radiographic testing we can get the recorded type results in the form of a radiographic film

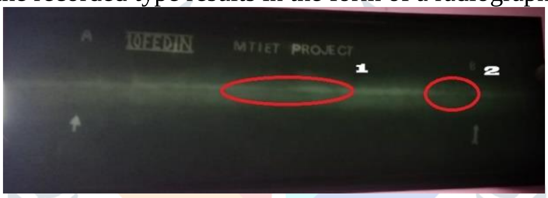


Fig 7.1: ***Radiographic film of Existing Parameters***

In the above test report mild steel material welded with existing parameters has come to show the defects in it named as lack of fusion and porosity and this is more than the non-significant defect (NSD)

7.1.2 Liquid Penetration test results

In the case of penetrant testing we can view the penetrant marks indications which will be exposed due to reverse capillary force.

Fig7.4: ***porosity indications***

In the penetration testing on mild steel material welded with existing parameters has come to show the defects it named as porosity and this is more than the non-significant defect (NSD) as shown in the above figure.

7.1.3 Ultrasonic testing results

The results in this are noted by the means of the flaw detector. In which there is a graphical representation

Fig 7.3: ***Ultrasonic testing flaw detector indication***

In the process of Ultrasonic testing we came to know the defects in the form of cracks and it is represented in the form of flaws in the flaw detector as shown in the figure above

7.1.4 Magnetic particle testing

In this case also the indications are show by the magnetics particle which forms an undesired shape on the surface after the magnetization is obtained in the areas of the defect.

Fig 7.4: ***Porosity indications by particle***

In the process of magnetic particle testing after introducing of magnetic Flux material all the particle get gather in the place where we get flux leakage and the method carried out in this is magnetic yoke type which can be easily portable

7.2 TEST REPORT OF MILD STEEL PLATE WELDED WITH AWS PARAMETERS

7.2.1 Radiographic testing results

By the radiographic testing we can get the recorded type results in the form of a radiographic film for AWS pareameters type

Fig 7.5: ***Radiographic film of Existing Parameters***

In the above test report mild steel material welded with AWS parameters has come to show that there is no more than the non-significant defect (NSD),hence this is accepated,When compared to the existing parameters defects to the AWS parameters defects the the weld is done without any lack of fusion and the other defects like cracks and porosity is minimised to the great extent. If the minimised defect is great than the non significant defect than the weld can not be accepted.

7.2.2 Liquid Penetration test results

In the case of penetrant testing we can view the penetrant marks indications which will be exposed due to reverse capillary force.

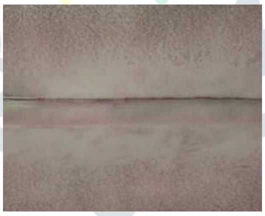


Fig 7.6: ***welded plate indicating less defects***

In the penetration testing on mild steel material welded with AWS parameters has come to show the less defects it named non-significant defect (NSD) as shown in the above figure.

7.2.3 Ultrasonic testing results

The results in this are noted by the means of the flaw detector. In which there is a graphical representation.

Fig 7.7: Ultrasonic testing flaw indication showing less flaws

In the process of Ultrasonic testing we came to know the defects are minimum cracks and it is represented in the form of flaws in the flaw detector as shown in the figure above

7.1.4 Magnetic particle testing

In this case also the indications are show by the magnetics particle which forms an undesired shape on the surface after the magnetization is obtained in the areas of the defect.

Fig 7.8: ***Porosity indications by particle***

Table 7.1 ***Defects in existing parameters vs AWS parameters***

Testing method	**Existing parameters**	**AWS parameters**
Radiographic testing	Lack of Fusion & porosity	No appearance of lack of Fusion. Minimal porosity visible.
Penetration testing	Porosity	Min. Reduced
Ultrasonic testing	Lack of Fusion ,Cracks	Min. cracks
Magnetic particle testing	Cracks	Minimal cracks

VIII. CONCLUSION

In this project we have Welded IS 2062 mild steel material with Existing Parameters and AWS parameters. We have tested each Specimen with Different NDT testing. Hereby conclude that

1) In Radiographic testing we found the lack of fusion and porosity as defect in the existing parameters weld and there is no any sort of lack of fusion and porosity in the AWS parameters weld.
2) Penetration testing we can determine only surface face defect up to 6 mm. we observed the porosity indications in the existing parameter weld compared to AWS parameters weld.
3) Ultrasonic testing we have seen many flaw indications in the welded which is done by Existing Parameters weld and minimum flaw indications in the AWS parameters weld.
4) Magnetic particle testing the defect can be seen in the form of flux leakage. There are numerous cracks in the weld done by Existing Parameters than the weld done by AWS parameters.

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