NDT of Dissimilar Metal Joint (SS-304 & MS-2062), Welded using Shielded Metal Arc Welding

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Abstract— The objective of this paper is to prepare defect free welding joint of dissimilar metal after welding under suitable condition and check the welded joint with different NDT processes. There has been an increasing demand for Nondestructive Testing (NDT) and Structural Health monitoring techniques to continuously monitor during all processes of a structure to prevent catastrophic failure and reduce maintenance costs. NDT methods aim to detect possible defects and characterize them (location and dimensions) so that their severity can be assessed, and the mechanical integrity of the welded components guaranteed. Experimental investigations confirm the challenges and significant shortcomings in the inspection of future industrial components where such microstructures are desirable for their mechanical properties.

Keywords: Mild Steel (2062, Grade-B), Stainless Steel (SS-304), SMA Welding, Weld Dissimilar Steels, Radiography Testing, Ultrasonic Testing

I. INTRODUCTION

Welding differing materials, such as Mild steel (MS-2062, Grade-B) and stainless steel (SS-304), can be a much more economical choice than fabricating a structure entirely with stainless steel. Base materials used for welding application will match perfectly in chemical and mechanical composition. However, companies in manufacturing, fabricating, construction and other industries may occasionally find it necessary — both for cost and service condition requirements - to weld together Mild steel (MS-2062, Grade-B) and stainless steel (SS-304). The welding of unlike materials is common in certain power generation facilities such as power plants, electronic, chemical industries, petrochemical and nuclear reactors principally to get suitable properties and reduce weight

A. Non Destructive Testing and its Benefits:

For the testing of welded surface, Nondestructive examination technique can be used to be examined the material without destroying anything. Surface and subsurface defects and size of flaws detected. To assure safety and reliability, it plays important role and is necessary. Examples are found in Thermal power plant, refineries, spacecraft (shuttle), aircraft, motor vehicles, pipelines, bridges; buildings and oil platforms which are all inspected using NDT.This Quality tool can give excellent results if it is used correctly. Mastery in the all testing techniques required for performing the tests.

NDT can be applied to every stage of an item's construction. The Welded product and materials can be examined using NDT and either accepted, rejected or repaired. This tool can then be used to monitor the integrity of the item or structure throughout its design life.

II. MATERIAL AND EXPERIMENTAL PROCEDURE

Stainless Steel (SS –304) is the standard "188" stainless steel, which includes 18% chromium and 8% nickel; it is the most compliant and universally used stainless steel.

Elements	C	Si	Mn	Ni	Cr	N	P	S
Weight %	0.08	0.75	2.0	8-10.5	18-20	0.1	0.045	0.03

Table 2.1: Chemical composition of SS-304 base metal, wt %

Hardness		Yield strength (N/mm²)	Tensile strength (N/mm²)	% Elongation
Rockwell B (HR B) max	Brinell (HB) max			
76	201	205	515	40 %

Table 2.2: Mechanical properties of SS-304 base metal

Mild Steel (Grade-B; IS: 2062)

Elements	C	Si	Mn	P	S	Fe
Weight %	0.18	0.40	0.90	0.04	0.04	Balance iron

Table 2.3: Chemical composition in weight % of Mild Steel (IS-2062; Grade-B)

Hardness Rockwell (HRB) max	Density,ρ Kg/mm³	Yield strength (N/mm²)	Tensile strength (N/mm²)	% Elongation
86	7.85	250	450-550	30 %

Table 2.4: Mechanical properties of Mild Steel (IS-2062; Grade-B)

A. Shielded metal arc welding process (SMAW)

The welding machine used in the present work for the welding of Stainless steel (SS-304) & Mild Steel (IS; 2062; Grade-B) plate are shown in fig 2.1. Its specifications are summarized in Table 2.8.

Fig. 2.1: ESAB make welding machine

Model	ESAB Arc 250
Manufacturer	Esab india limited, Kolkata
Mains voltage V/ph, Hz	230/1, 50
Setting range (DC) A	5-180
Open circuit voltage, V	60-75
Dimensions l*w*h, mm	380*180*300
Weight, kg	8

Table 2.5: Specifications of welding machine

Parameter	1st pass	2nd Pass
Current	80	90
Voltage	28	30
Polarity	DCEP	DCEP
Electrode	E309L	E-309L
Electrode Dia.	3.15mm	3.15mm
Electrode length	350mm	350 mm
Welding position	2G	2G
Welding speed	250mm/min	250mm/min

Table 2.6: SMA welding parameters for further two pass

B. Welding Electrode:

ANSI/AWS A5.4 & ASME SFA 5.4 E 309L-16

Elements	Wt. %	Elements	Wt. %
C	0.4	Ni	12-14
Mn	0.5-2.5	Mo	0.75
P	0.04	Co	0.75
S	0.03	Normal Ferrite	4-10
Cr	22-24		

Table 2.7: Chemical composition of E-309 L electrode, wt. %

C. Radiography Testing:

In this present study the X-ray radiography (NDT) was used to inspect the internal flaws or discontinuities, present in the weld metal. The Radiography testing has conducted under following conditions, shown in Table 3.11

Material	SS & MS
Ref. Radiograph	ASTM E-390Vol.II
Thickness	10 mm
Focal Size	3 mm
Film Type	Agfa D-7
Intensifying Screen	Lead screen(0.13 & 0.25mm)
IQI	ASTM 20 Hole Type 17 Th
Focus to Film distance	90 cm
Technique	SWSI
Density	2.18
Sensitivity	2-2T

Table 3.11: Reference Standard ASTM-446

D. Ultra sonic Testing:

Ultrasonic Inspection is a very useful and versatile NDT technique. High frequency sound energy is used to perform testing and take measurements. Flaw detection/evaluation, dimensional measurements, material characterization, and more defects checked using Ultrasonic inspection method.

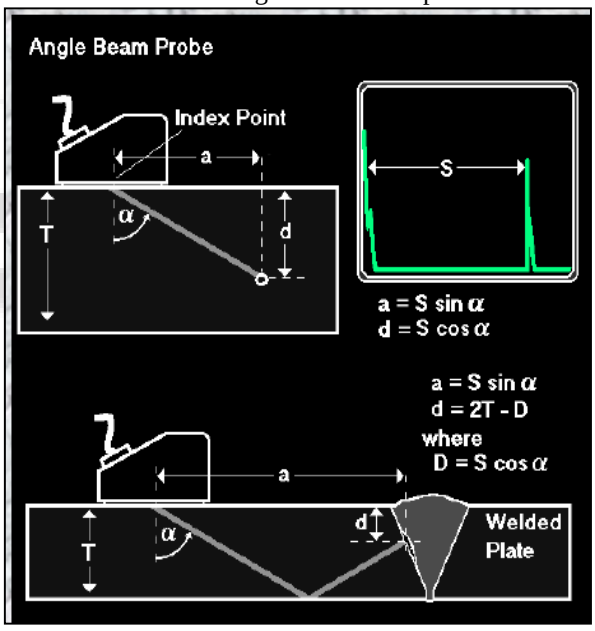

Fig. 3.5: Angle beam probe

MATERIAL THICKNESS	40MM	TIME BASE RANGE	0-150
SIZE	2500X12000	CALIBRATION GAIN	45DB
EQUIPTMENT MAKE	Modsonic Einstein II-DGS	COUPLANT USED	Mobile oil
TRANSDUCER TYPE & SIZE	45*	SURFACE TEMP.	Ambient
TEST FREQUENCY	4MHZ	SURFACE CONDITION	Smooth
CLABRITION BLOCK	V1, V2 BLOCK	FLAW SIZE EVALUATION	According AWS D1.1 2010
AMPLITUDE REFERENCE	80%	SCANNING SPEED	150mm/sec
OBJECTIVE	Quality Assurance	SCANNING COVERAGE AREA	100% OF WELD

Table 3.11: Reference Standard ASTM-446

III. RESULTS AND DISCUSSION

The result of NDT on the welded joint of the Stainless Steel (SS-304) and Mild steel (IS-2062; Grade-B) are shown below. Internal flaws or discontinuities such as cracks, Slag Inclusion, Gas Porosity and Lack of fusion have been observed and repaired.

A. Radiographic Testing:

Types of defects/ Results obtained	Slag inclusion	Gas porosity	Lack of Fusion	Pin Hole
Test Sample -1	Nil	Level-1	Level-5	Nil
Test Sample-2	Nil	Nil	Level-5	Level-2
Test Sample -1(After repair)	Nil	Nil	Nil	Nil
Test Sample-2(After repair)	Nil	Nil	Nil	Nil

Table 4.1: X-ray Radiography results

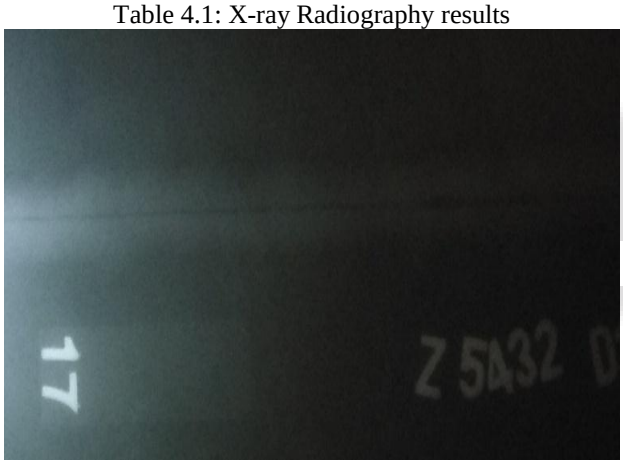

Fig. 4.1: X-Ray Radiography show LOF

B. Ultrasonic Testing:

Types of defects/ Results obtained	Slag inclusion	Gas porosity	Lack of Fusion	Pin Hole
Test Sample -1	Nil	Level-1	Level-5	Nil
Test Sample-2	Nil	Nil	Level-5	Level-2
Test Sample -1(After repair)	Nil	Nil	Nil	Nil
Test Sample-2(After repair)	Nil	Nil	Nil	Nil

Table 4.2: Ultrasonic testing results

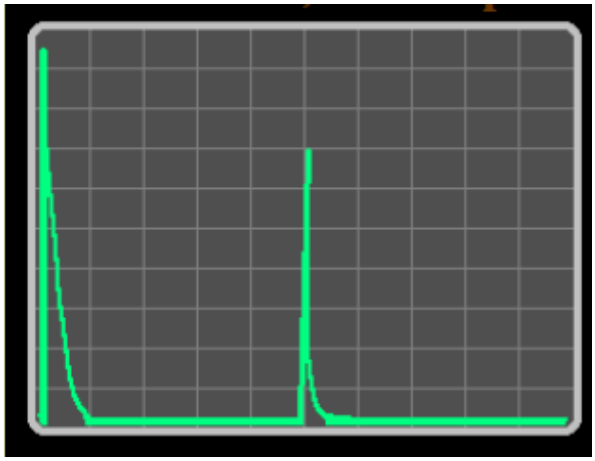

Fig. 4.2: Lack of fusion

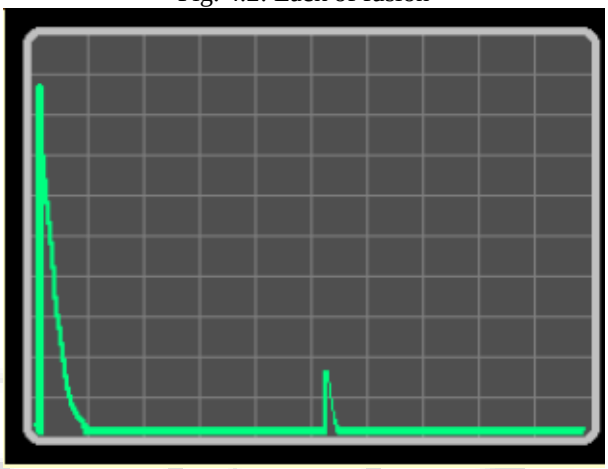

Fig. 4.3; Pin Hole

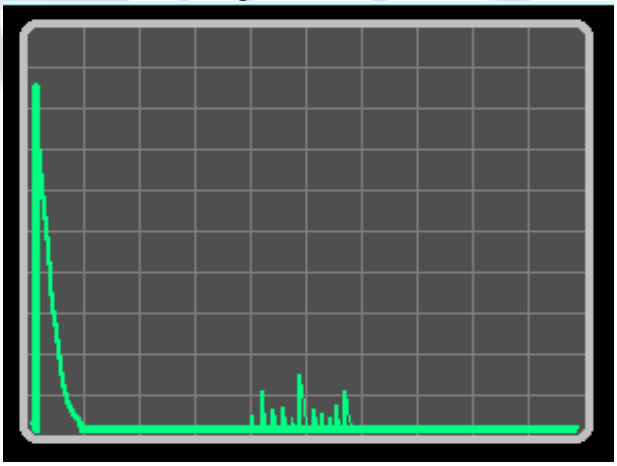

Fig. 4.4: Porosity

IV. CONCLUSIONS

From the study, following conclusions can be drawn:

1) NDT results verify the procedure of fabrication of realistic defects.
2) The main flaw which occurs in welding dissimilar material by SMAW is the development of cracks, Porosity and LOF during the welding, which needs more effort for achieving weld by SMA welding.
3) In order to get optimum monitoring and test for a structure status, it is important to implement NDT method.

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