https://doi.org/10.15623/ijret.2018.0707013 Received: 30-04-2018, Accepted: 11-06-2018, Published: 02-07-2018

EFFECT OF POST WELDING HEAT TREATMENT ON MECHANICAL PROPERTIES OF GTA WELDED SA 516 GRADE 70 CARBON STEEL

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Abstract

This investigation was carried out with the aim of studying the effect of Post Weld Heat Treatment (PWHT) on the mechanical properties of SA-516 Grade 70 weld joint. The objective was to identify the effect of post weld treatment temperature on mechanical properties like tensile strength, hardness & bending strength of weld joint. In order to optimize heat treatment conditions, different PWHT temperature were applied with one hour holding time & furnace cooling. Range of temperature selected below the Ac1 temperature from 550°C to 640°C with a span of 30°C interval. Heat treatment process were carried out in muffle furnace with high heating rate. To assess the effect of different treatment schemes on the mechanical properties, hardness, tensile strength and bend strength have been employed on these weld joints. Preparation of specimen for testing were as per the ASTM A-307. The results show that the there is a substantial increment of tensile strength as increasing PWHT temperature where hardness value is decrease as increasing PWHT temperature.

Keywords: *PWHT, ASTM A-370, Tensile strength, and Bend Test*

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1. INTRODUCTION

Welding is a joining process of materials by heating them to suitable temperatures with or without the application of pressure or by the application of heat alone, and with or without the use of filler material. Welding is used for making permanent joints. There are many ways to do this and these require a high degree of skill and advanced technology [1].There are several different ways to weld, some involve amazing machinery and revolutionary technology, including electron beams, lasers, ultrasonic.

1.1 Heat Treatment

Paragraph comes It is a treatment to bring the heat of steel or metal at a specific temperature to accomplish certain properties. To achieve dimensional stability in order to maintain tolerances during machining operations. To produce specific metallurgical structures in order to achieve the required mechanical properties [2]. To reduce the risk of problems such as stress corrosion or brittle fracture by reducing the residual stress in the welded component.

1.2 Post Welding Heat Treatment

Post Weld Heat Treatment is a type of thermal treatment which is employed to material primarily after welding. This technique is a common practice, which is exercised in industries to adjust the mechanical properties of weldment. The required welded material is allowed to heat, usually at lower temperature in order to prevent any phase change.

2. EXPERIMENTAL DETAIL

2.1 Material

In the present study, the base metal was used in the form of SA 516 Gr 70 carbon steel plate with dimension 350 mm × 550mm × 10 mm. The ER 70S-2 solid rode of electrode of 2.4 mm diameter was selected for the present research work. The chemical composition of base metal and filler metal are shown in the table 1.

Table -1: Chemical Composition of SA516 Gr-70 (Weld material)& ER70 S-2(Filler material)

Material	C	Mn	Si	Al
SA516 GR 70	0.20	1.05	0.32	0.04
ER70S-2	0.15	0.9-1.4	0.45-0.7	0.05-0.15
Material	P	S	Ti	Zr
SA516 GR 70	0.015	0.008	-	-
ER70S-2	0.03	0.04	0.05 0.15	0.02-0.12

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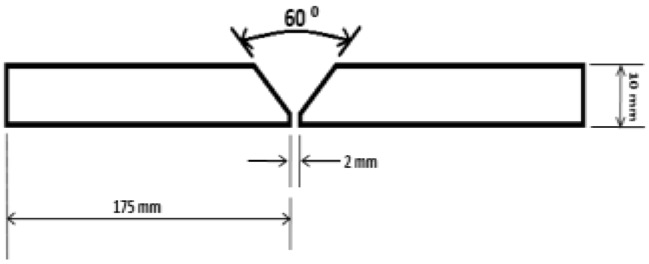

Fig -1: Joint preparation

Table -2: Weld joint Dimensions

Included Angle	Angle of Bevel	Root Gap(mm)	Root Face(mm)
60°	30°	2	1.5

2.2 Welding Procedure

Gas Tungsten inert gas (GTAW) is an arc welding process in which heat is produced between a non –consumable tungsten electrode and the work metal. The heat of arc is sufficient to melt the base metal and produces weld pool in the presenceof inert gas [3]. It is also used to join different material with high quality weld bead. The welding came into existence from "Bronze Age" about 2000 years ago [1]. In current study GTAW welding process consider due to its high quality welding.

In any welding process selection of welding parameters are directly effect on structural integrity as well as strength. In this study parameters of welding are selected as per the standard practice.

Table 3: Welding parameters

Current	Voltage	Travelling Speed
200A	14 V	57 mm/minute

(This parameters are change with plate thickness)

2.3 Post Welding Heat Treatment

Post weld heat treatment of all samples was carried out in a muffle furnace.In order to optimize heat treatment conditions, different PWHT temperature were applied with one hour holding time & furnace cooling [3]. Range of temperature selected below the Ac1 temperature from 550 c° to 640 c° with a span of 30 c° interval. The PWHT in was done in Muffle Furnace [Fig-2] with High heating rate(37°C/min) and furnace cooling(1.4°C/min.)[Fig-3].

Fig -2: Muffle Furnace (High Heating)

Fig -3: Muffle Furnace (Cooling)

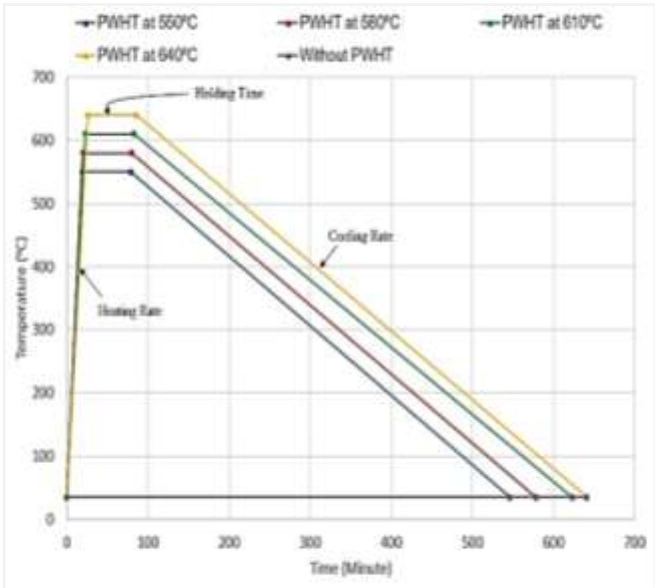

Chart -1: Heating and cooling rate

3. RESULT AND DISCUSSION

The Tig welded SA 516 Gr 70 samples are characterized for mechanical Properties namely tensile, bend, hardness.

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3.1 Mechanical Properties Characterization

3.1.1 Tensile Test

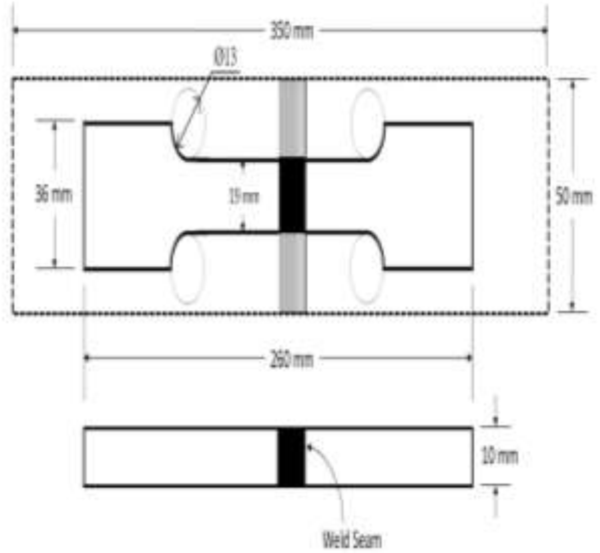

Fig -4: Tensile test specimen dimensions in mm as per ASTM A307

Tensile testing of cross-weld samples was carried out to quantify the tensile properties of the weld-ment, and also determine the location of failure.

3.1.2 Results for Various PWHT Temperature and for without PWHT Sample

Fig -5: PWHT Test

Table -3: Reading Table

	PWHT Temperature (°C)	Thickness (mm)	Width (mm)	Area (mm^2)	Ultimate Load (N)	Ultimate Tensile Strength (N/mm^2)	Fracture
Sample -1	-	10.04	18.94	190.15	100499	529	At Weld
Sample -2	550	10.01	19.04	190.59	103820	545	At Weld
Sample -3	580	10.04	19.11	191.86	96499	503	At Weld
Sample -4	610	9.90	19.05	188.59	101740	539	At Weld
Sample -5	640	9.89	19.12	189.09	100780	533	At Weld

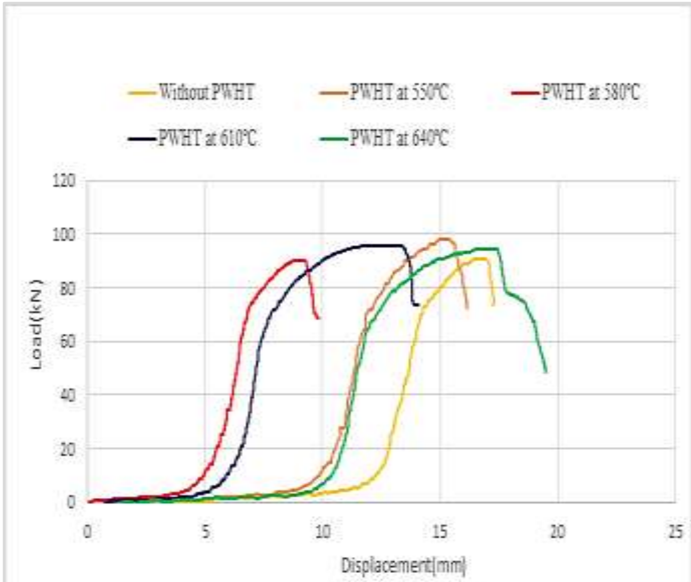

Fig 6: Load-Displacement graph for all PWHT Temperatures

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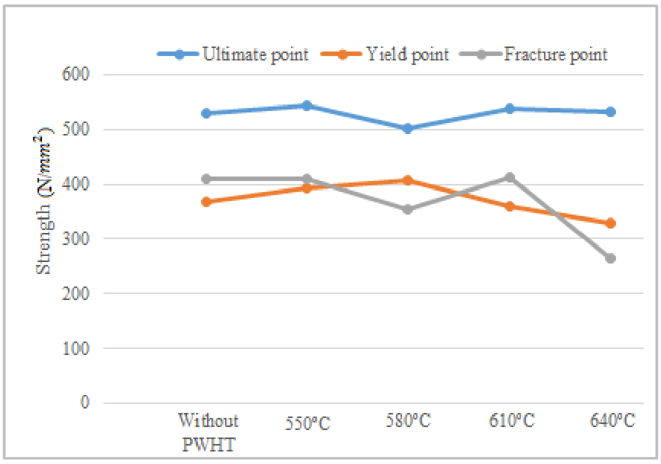

Fig 7: Graph of Ultimate strength, Yield strength, Fracture strength for all PWHT Temperatures

Figure 7 shows the graph of ultimate, yield and fracture strength for all samples. As per the graph result the ultimate strength is higher for PWHT at 550°C and 610°C samples than without PWHT sample. Yield strength is decreasing as PWHT temperature increase but after PWHT at 580°C it decreasing. Fracture strength is decreasing as PWHT temperature increase but PWHT at 610°C, it is at maximum.

3.1.2 Bend Test

Bend test is one of the most important and commonly used destructive tests to determine the ductility and for the presence porosity, inclusion, penetration and other macro-size internal weld discontinuities of the weld joint produced using under one set of welding conditions [1]. The severity of the bend test is primarily a function of the angle of bend to which the specimen is bent, and of the cross section of the specimen.

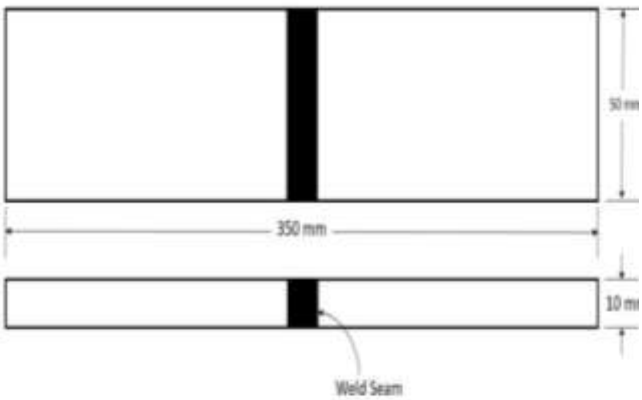

Fig 8: Bend Test
Sample 1: Without PWHT

Fig 9: Bend test sample 1 (Without PWHT)
Sample 2: PWHT at 550ºC

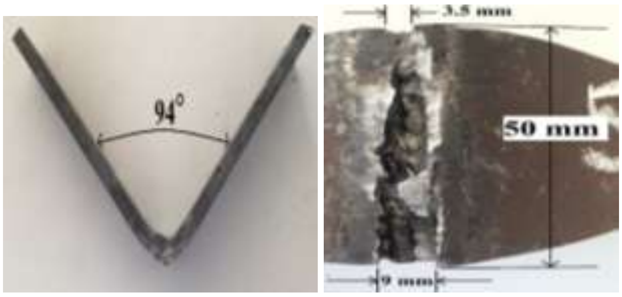

Fig 10: Bend test sample 2 (PWHT at 550ºC)
Sample 3: PWHT at 580ºC

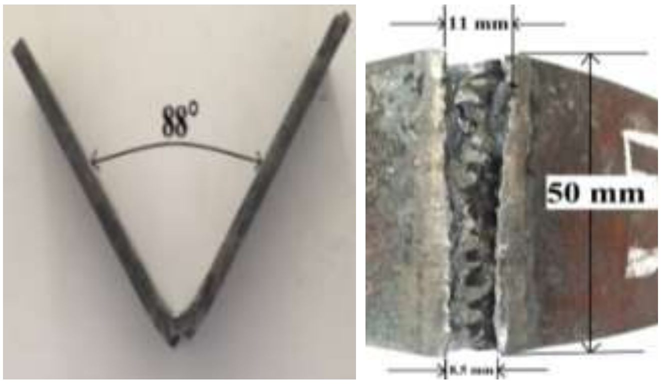

Fig 11: Bend test sample 3 (PWHT at 580ºC)
Sample 4: PWHT at 610ºC

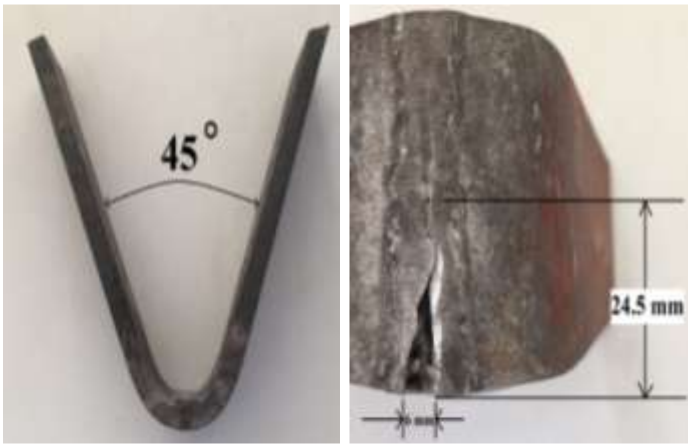

Fig 12: Bend test sample 4 (PWHT at 610ºC)
Sample 5: PWHT at 640ºC

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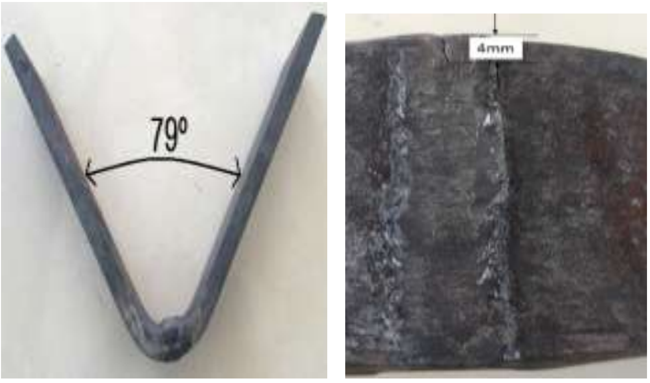

Fig 13: Bend test sample 5 (PWHT at 640ºC)

Table -4: Result Table

PWHT Temperature	Bending Angle	Crack Length(mm)	Minimum Crack Width(mm)	Maximum Crack Width(mm)
Without PWHT	55°	38	0.1	0.3
550°C	94°	50	3.5	9
580°C	88°	50	8.5	11
610°C	45°	24.5	0.5	6
640°C	79°	4	0.5	1

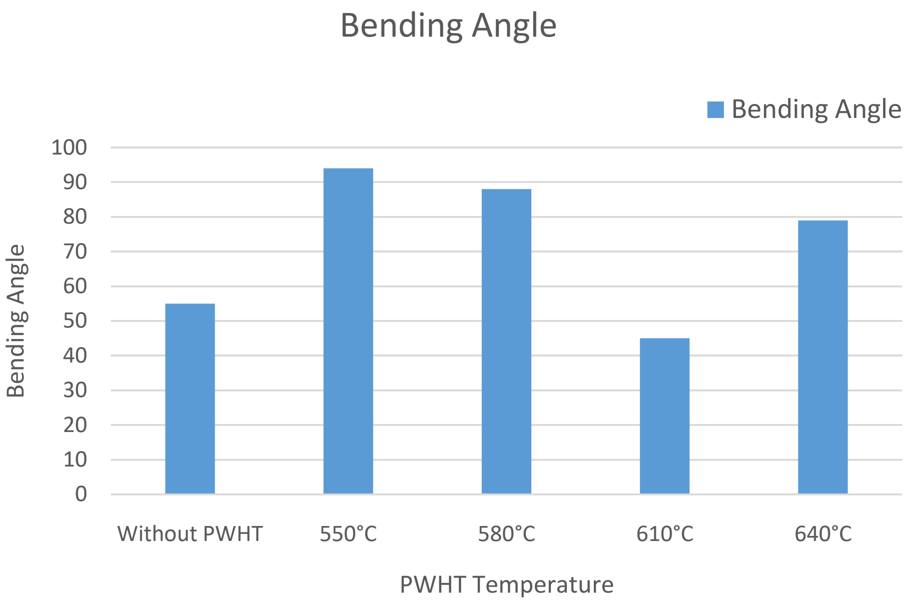

Chart -2: Bending angle for various PWHT temperature

Figure 6.18 shows the graph of bending angle for various PWHT temperature. As per the graph result when the temperature is increased, the bending angle become larger than sample of without PWHT But at 610°C, it become smaller than sample of without PWHT.

3.1.3 Hardness Test

In a hardness testing, five point is considered for measurement on Vickers cum brinnel hardness tester by applying a 10kg load. During a testing one point selected at a weld center line, two point selected on HAZ and two point is selected on base metal.

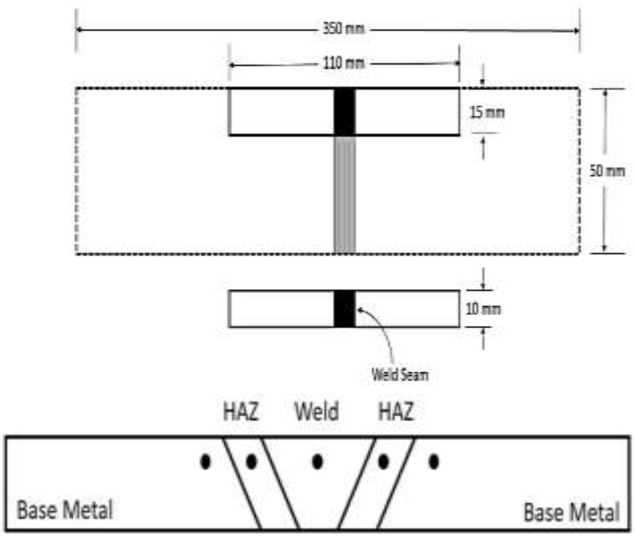

Fig 14: Hardness Test

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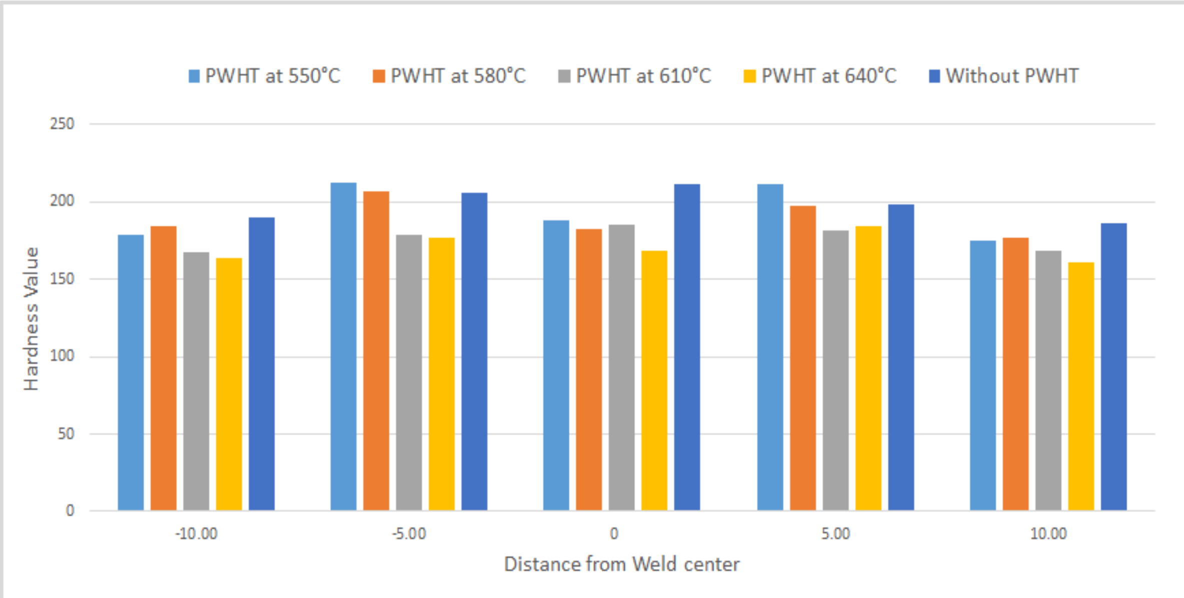

Chart -3:

	Temperature	Location 1 (Base metal)	Location2 (HAZ)	Location3 (WELD)	Location4 (HAZ)	Location5 (Base metal)
Sample 1	Without PWHT	189.66	205.33	211.33	198..33	185.66
Sample 2	550°C	178.33	212.66	188.33	211.33	175.33
Sample 3	580°C	184.33	206.66	182.66	197.66	176.66
Sample 4	610°C	167.66	178.66	185.33	181.66	168.66
Sample 5	640°C	163.66	176.33	168.33	184.33	160.66

4. CONCLUSION

In experiment here applied PWHT in muffle furnace at high heating rate and low cooling rate. Here we have increased the temperature of number of specimen at various temperature. After testing we have conclude that:

- In tensile test, during PWHT when the temperature is increased the UTS of material is increased.
- In Bend test, when the temperature is increased the crack propagation is decreased with small bend angle.
- In Hardness test, with increase in PWHT temperature,the Hardness value at welding section, HAZ and base metal is decreased.

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