Effect of Post Weld Heat Treatment Mechanical Properties on Welded Joints of SA516 GR70 Material

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Abstract: Heat treatment is an important operation in the final fabrication process of many engineering machinery. Only by heat treatment it is potential to impart high mechanical properties to steel parts & tools for sophisticated purpose. Heat treatment is considered to be very important tool of the metallurgist by which it can alter the properties of steel easily. Post weld heat treatment temperature influences the properties of weldment which directly affect the weld joints strength. Improve weld joint strength increase the structure integrity of weldment so it's important to understand the effect of different post weld heat treatment temperature on weldment. This study aimed at the investigation of the effect of pre-heating on the mechanical & microstructure properties of weldment.

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1. Introduction:

1.1 What is Welding?

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. There are several different ways to weld; some involve amazing machinery and revolutionary technology, including electron beams, lasers, ultrasonic.

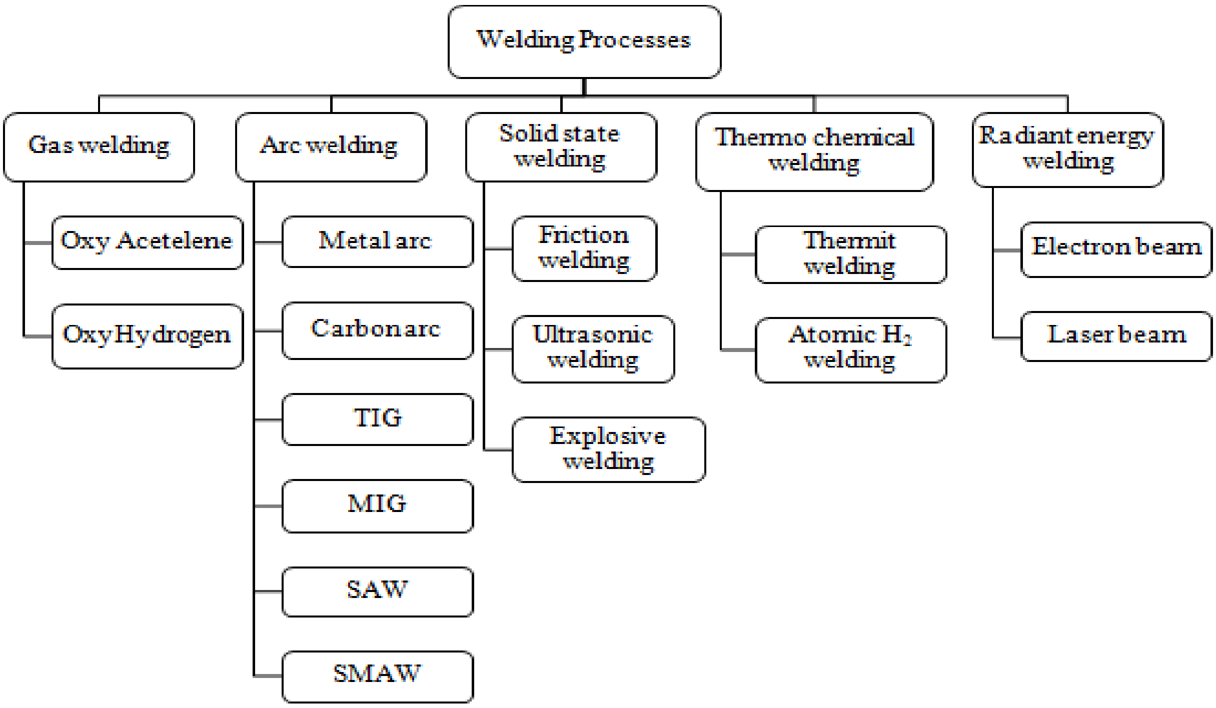

Figure 1 Classification of welding process

1.2 Heat Treatment:

It is a treatment to bring the heat of steel or metal at a specific temperature to accomplish certain properties.

Need of heat treatment : 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. To reduce the risk of problems such as stress corrosion or brittle fracture by reducing the residual stress in the welded component.

Types of heat treatment processes: Prewelding Heat treatment

Postwelding 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. Methodology

2.1 Material:

SA516 GRADE 70 is an excellent choice for service in lower than ambient temperature application, has excellent toughness and is used in both pressure vessels and industrial boilers. It offers a greater Yield and Tensile strength when compared to ASTM SA516 Grade 65 and can operate in lower temperatures.

Material for experiment:

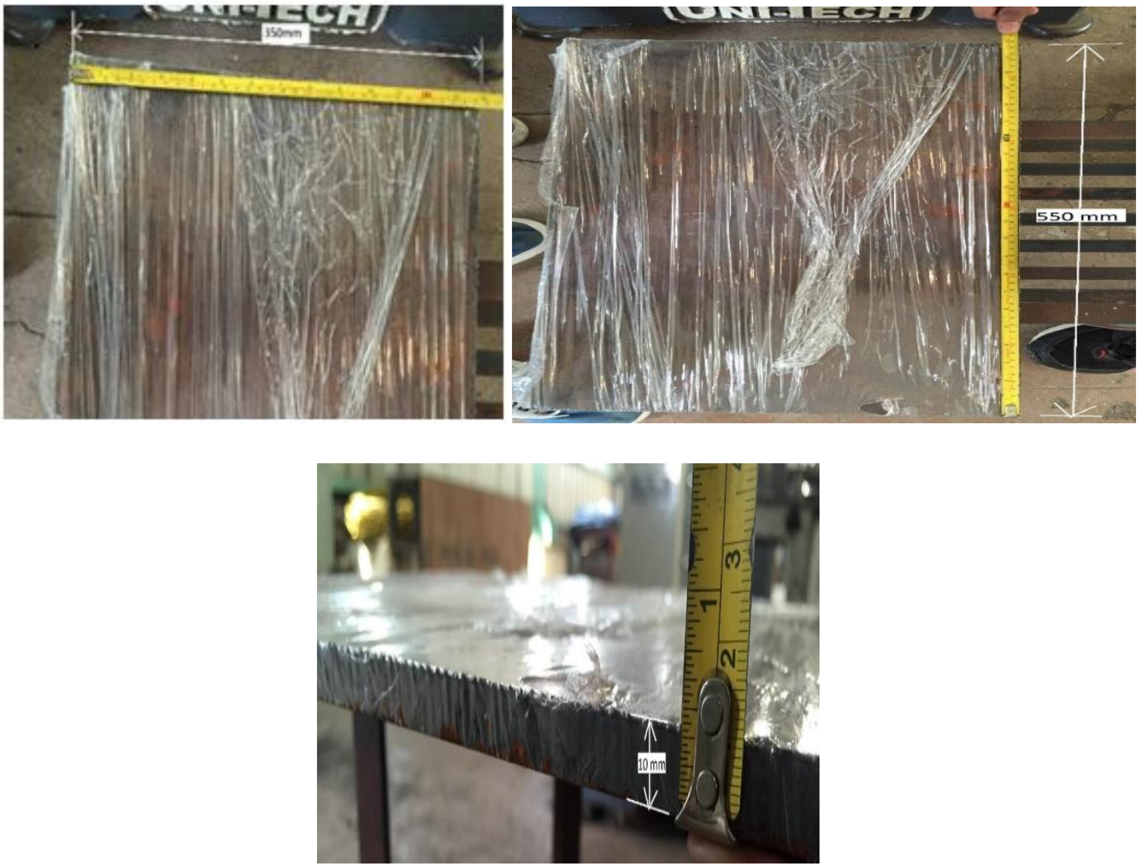

Figure 2 Material SA516 GR70

2.2 Material cutting Method:

The plate has been spitted in two part as dimension 160*85*6 by Water jet CNC cutting machine.

Why Water jet CNC cutting machine?

In this machine, A water jet cutter is an industrial tool capable of cutting a wide variety of materials using a very high-pressure jet of water, or a mixture of water and an abrasive substance. An important benefit of the water jet is the ability to cut material without interfering with its inherent structure, as there is no heat-affected zone (HAZ). Minimizing the effects of heat allows metals to be cut without harming or changing intrinsic properties.

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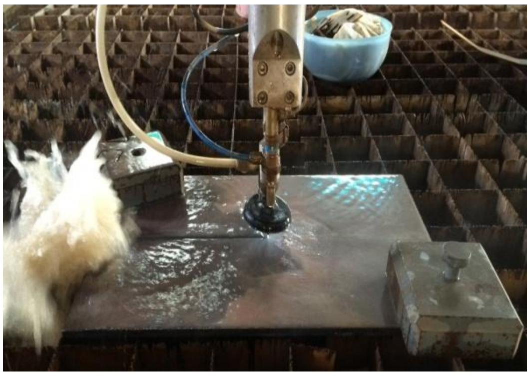

Figure 3 Water jet CNC

2.3 Welding Process:

The TIG welding is also known as a Gas tungsten arc welding (GTAW).TIG welding is an arc welding process that use tungsten electrode to produce the welding. The weld area is protected from atmospheric contamination by an inert shielding gas (argon or helium), and a filler metal is normally used. In TIG welding an arc is formed between a non-consumable tungsten electrode and the metal being welded. Gas is fed through the torch to shield the electrode and molten weld pool. If filler wire is used, it is added to the weld pool separately.

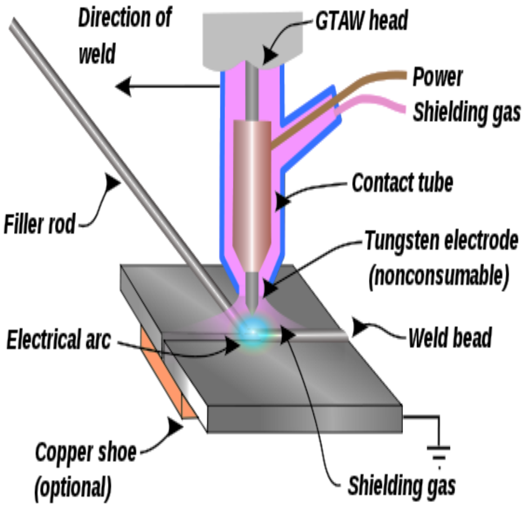

Figure 4 Nomenclature of Welding

2.4 Procedure for PWHT:

The PWHT in this experiment was done in Muffle Furnace for No. of temperatures at High heating rate(37°C/minute) and furnace cooling(1.4°C/minute).

Range of temperature :

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.

2.5 Tensile Test procedure:

The basic test for determination of material behaviour is the tensile test. Tensile testing of weld samples was carried out to quantify the tensile properties of the weldment, and also determine the location of failure. Tensile test specimen is shown in figure 5.

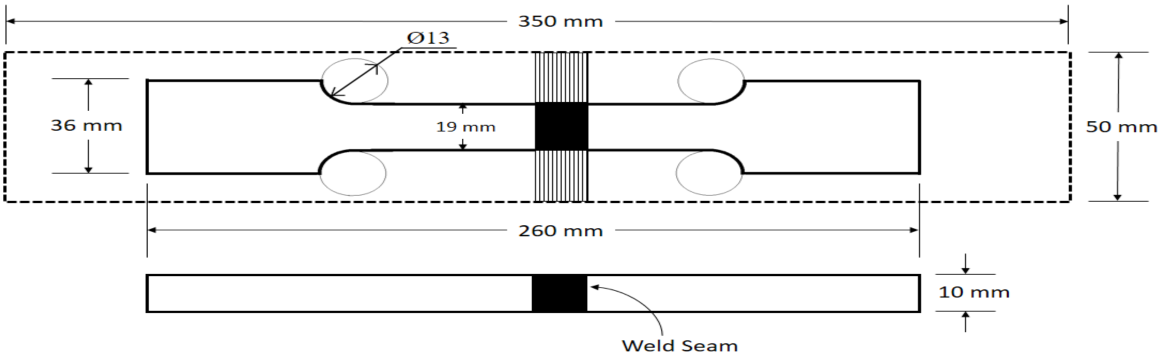

Figure 5 Tensile specimen

2.5 Bend Test procedure:

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. 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. Bend test specimen is shown in figure 6.

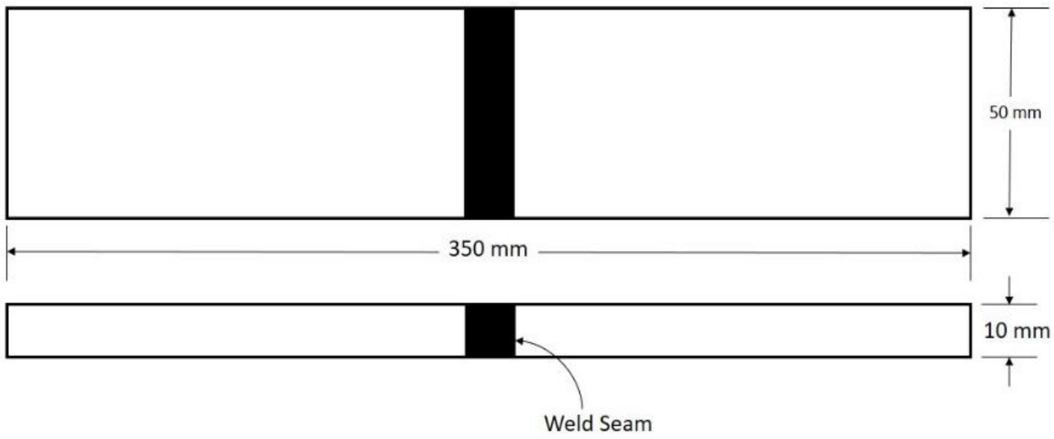

Figure 6 Bend specimen

2.6 Hardness Test procedure:

Hardness testing was carried out to evaluate the effect of PWHT on this property, and to assess the properties of the three regions (Weld section, Heat Affected Zone, Base metal) of weldment. Hardness test specimen is shown in figure 7.

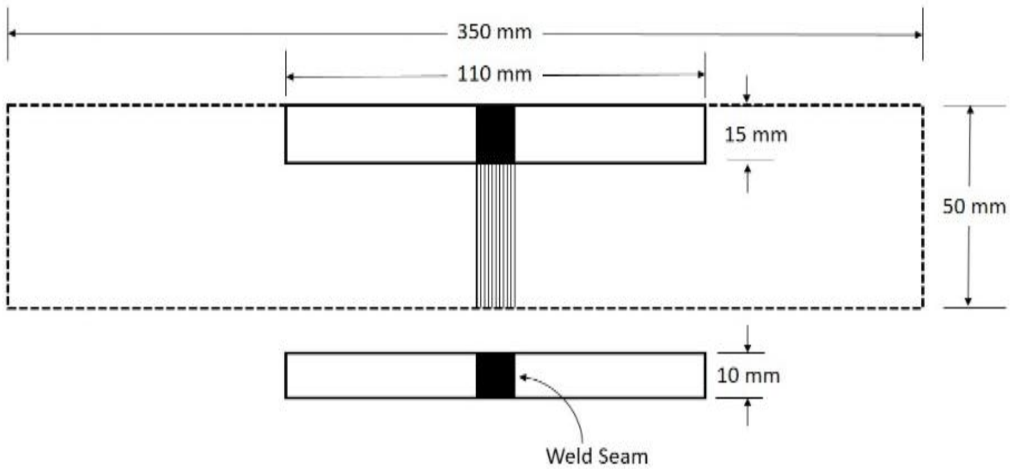

Figure 7 Hardness specimen

3. Result

3.1 Tensile test result:

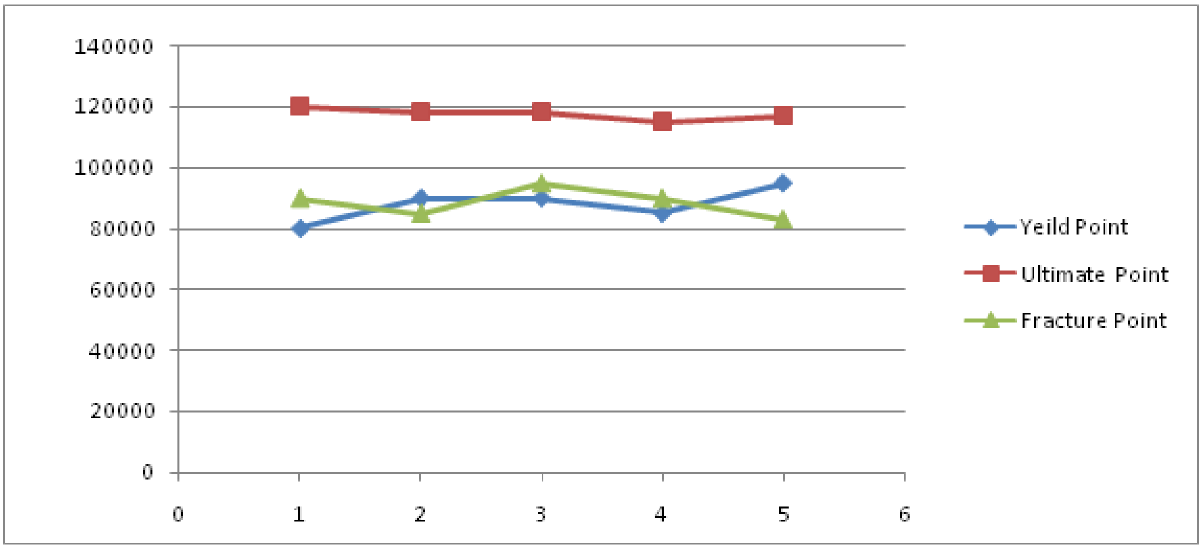

Figure 8 Strength (N/mm^2) Vs Temp. (°C)

From fig. 8 we can see that ultimate strength of without PWHT (Point 1 in graph) specimen is higher than other specimens. Yield strength is decreasing as PWHT temperature increase but after PWHT at 580 °C (Point 3 in graph). Fracture strength is decreasing as PWHT temperature increase but PWHT at 580 °C, it is at maximum.

3.2 Bend test result:

Bend angle of all specimen are 180° & we observed that 2 specimen (550 °C & 610 °C)get crack (<3 mm) that we can easily observed and remaining three specimen passed this test successfully.

3.3 Hardness test result:

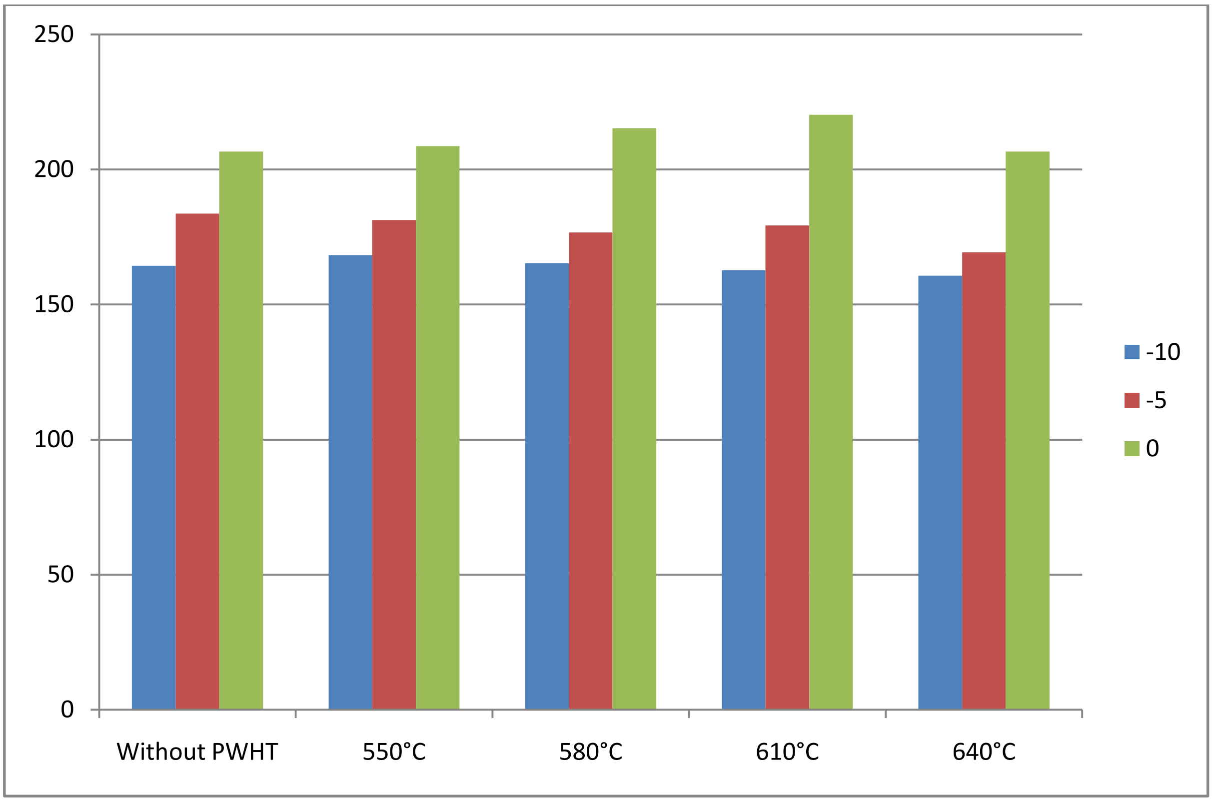

Figure 9 Hardness value Vs Temp. (°C)

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In hardness test with increasing PWHT temperature the hardness value of welding section is greater than HAZ and base metal (Color code of fig.9: Green: Weld zone, Red: HAZ, Blue: Base metal).

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