

Determination of Optimum Post Weld Heat Treatment Processes on the Microstructure and Mechanical Properties of IS2062 Steel Weldments

Chennaiah MB^{1*}, Kumar PN² and Rao KP³

¹Assistant Professor in ME Department, V.R.Siddhartha Engineering College, Vijayawada, India

²Professor in ME Department, N.B.K.R Institute of Science and Technology, Vidyannagar, India

³Professor in ME Department, J.N.T.University College of Engineering, Ananthapuram, India

Abstract

This study investigates the effect of post heat treatment on the microstructure and mechanical properties of IS2062 steels. Similar metal joints of IS2062 weldments are prepared by using MIG welding process. This melting is occurring at edges of the plates because of sufficient amount of heat energy is passing over the plate per unit time and density of energy is supplied to the wire. In this connection, heating and cooling of weldment some of the disturbances in metallurgical and mechanical point of view. To overcome we will choose suitable post weld heat treatment to avoid the disturbances and improve industrial requirement irrespective of the mechanical, microstructure of the weldment. The objective is to determine the optimum post weld heat treatment method for the IS2062 steel. After welding, the effects of post weld heat treatment on weld metal microstructure and mechanical properties including weldment tensile strength, impact and hardness over the room temperature range 32°C are investigated. In particular this study the effect of these properties to understand estimate heat treatments on the tensile impact, Hardness materials are considered as weldments before heat treatment and after post weld heat treatment.

Keywords: Heat input; Mechanical properties; Post weld heat treatment; Welding zone; HAZ

Introduction

In any welding technique can be heating and cooling of the parent materials, strength setup of the entire materials can be obtained overmatched depending upon the temperature or heat energy is transferred in to the parent materials. This overmatched strength of the welded metals often restricts some of the welding processes are controlled, but metallurgical point of view it is not suitable for entire material to maintain uniformity. So researcher chooses the post weld heat treatment processes to improve the tensile, impact and hardness of the parent metals in order to choose optimal post weld heat treatment processes increasing the mechanical and metallurgical results, which derive the industrial requirement and literature [1,2]. To improve mechanical properties in pressure vessels and boilers of thicker sections, considerable research efforts have been directed and many papers have described the methods of improving mechanical properties by conducting tests and results. The literature survey provides on post weld heat treatment, shows the effect of post weld heat treatment on certain mechanical properties and the problems arising during post weld heat treatment. The toughness of the CGHAZ recovers the slowest as a function of increasing post weld heat treatment temperature and remains low until a 730°C heat treatment. To guarantee an adequate HAZ toughness, a minimum post weld heat treatment temperature of 730°C for 2 h is recommended. This recommendation agrees with the ASME code required 732°C minimum tempering temperature for the base metal. Ahmad studied the effect of a post-weld heat treatment (post weld heat treatment) on the mechanical and microstructure properties of an AA6061 sample welded using the gas metal arc welding (GMAW). The welded samples were divided into as-welded and post weld heat treatment samples. The post weld heat treatments used on the samples were solution heat treatment, water quenching and artificial aging. Both welded samples were cut according to the ASTM E8M-04 standard to obtain the tensile strength and the elongation of the joints. A Vickers micro hardness testing machine was used to measure the hardness across the joints. By implementing post weld heat treatment, a 3.8% increase was recorded for tensile strength, hardness strength was

increased by 25.6% and a 21.5% higher elongated was achieved. The results proved that post weld heat treatment was able to enhance the hardness strength and tensile properties of AA6061 welded joints using GMAW. The higher values of hardness, tensile strength and elongation are due to the fact that post weld heat treatment produces a fine and uniform distribution of precipitates at the weld joints.

Sample Preparation

The experiment was performed on samples which were made with specific dimensions of approximately 250 x 100 x 10 mm single V-type grooved samples are prepared from IS2062 as main test plate. The chemical composition of IS2062 and filler material is shown in Table 1. Filler metal as MIG wire (Copper Coated Mild Steel) with diameter 1.2 mm is taken. The importance of copper coating on Mild steel is used to prevent rust and also current to pass current easily. The steel has a 0.22% of carbon content; as a result weldability and toughness are improved. These plates having the same type groove are welded together using MIG welding processes. As we have considered 10 mm thickness plate, before doing Welding we have to preheat (100°-150°C) the materials in order to prevent the moisture in the metal, distortion control and also for cracks rectification. 16 samples are prepared by using welding parameters of current 160-180 amp, voltage 26-30 V, welding speed 3.3-3.5 mm/sec. 4 samples are before post weld heat treatment and remaining after post weld heat treatment processes is conducting as

***Corresponding author:** Chennaiah MB, Assistant Professor in ME Department, V.R.Siddhartha Engineering College, Vijayawada, India, Tel: 08662582333; E-mail: chennai303.mech@vrsiddhartha.ac.in

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S.No	Name of Material	Composition in % of Weight						
		C	Mn	Si	Cr	S	P	Mg
1.	Mild steel (IS 2062)	0.22	1.5	0.40	-	0.045	0.045	-
2.	Copper Coated Mild Steel	0.1	1.86	0.73	0.2	0.30	0.03	-

Table 1: Chemical composition of IS2062 and filler material.

follows, namely Annealing, Normalizing, Tempering conditions [3]. The MIL-STD welding procedure is followed in preparation of IS2062 weldment [4].

Tensile test samples

The tensile test samples are prepared as per procedure is used to cut from the weldment. While conducting tensile test firstly, to measure the initial length and the diameter of the test piece and noted and then test piece is mounted on the testing machine and then apply load and after sometime test piece is elongated and necking is formed and then loading process continued until fracture. This test is conducted for test pieces of 4 joints. Heat treatment is as stage in the fabrication of structures and is often forgotten; but it has perhaps more wide-reaching and important ramifications than many of the other stages in the fabrications of structures or components. Especially at the welded zone careful observation is required, the test values are tabulated in the Table 1.

Impact test samples

This test samples are prepared and tested as per ASTM-IS2062 procedure [5,6]. The samples are cut longitudinally to the weld axis with notch in the middle of the welded area as shown in Figure 1. This work is carried out at room temperature.

Hardness

The sample preparation and evolution is carried based on ASTM procedure [7]. The hardness measure is done at different zones of weldment namely base metal, HAZ and WZ, and their values are tabulated.

Microstructure- a process methodology

Welding processes and the associated heating and cooling of edges of the similar plates leading to the development of different microstructures in different zones have been observed. For metallographic observation before post weld heat treatment and after post weld heat treatment specimens were etched with 4% nital for 20 s and consequently the microstructures of the base, weld and the heat affected zone were defined. Specimens were prepared for Electron Back Scattered Diffraction (EBSD) analysis using standard sample preparation method. A Zeiss 940SEM with a tungsten filament was used. The SEM device is coupled with automatic OIMTM (Orientation Imaging Microscopy) software [8-10].

Results and Discussion

Tensile test

The tensile test is conducted on before post weld heat treatment and after post weld heat treatment on test specimens. One of the most significance observation at annealing conditioned test sample given higher value than the other samples (Figure 2 and Table 2).

Impact strength

While conducting Impact test firstly we have to prepare the test

piece as per dimensions by using milling machine and also by using V cutter in order to make a notch up to 2 mm thickness. The arrangement of test setup consist of big size of pendulum is used to hit the prepared samples at an standard height, at the same time the amount of energy is absorbed by the samples from the pendulum to fracture the test samples, the results obtained from the testing machine. Here the minimum impact energy in before heat treatment and maximum at annealing condition test sample (Figure 3 and Table 3).

Hardness

Hardness was found to be a reliable method of estimating the yield and tensile strength of the different zones of the weldment before post weld heat treatment and after post weld heat treatment. The tensile data obtained from the sections of B.M, W.Z and HAZ could be useful to



Figure 1: Test samples of tensile and impact.

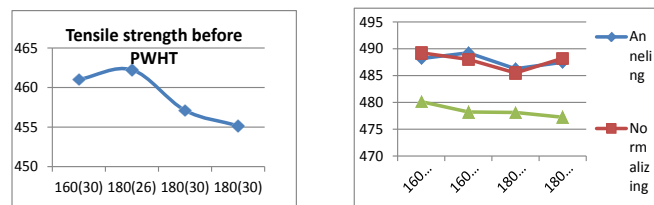


Figure 2: Tensile strength for IS 2062 and IS 2062 joint at B.H.T and A.H.T processes.

	Current (Amps)	Voltage (Volts)	Tensile strength (N)			
			Before post weld heat treatment	After Annealing	After Normalizing	After Tempering
1	160	26	461.01	488.17	489.23	480.12
2	160	30	462.24	489.23	488.01	478.21
3	180	26	457.112	486.27	485.49	478.11
4	180	30	455.16	487.48	488.23	477.22

Table 2: Before post weld heat treatment & after post weld heat treatment processes of IS 2062 welded joints tensile strength.

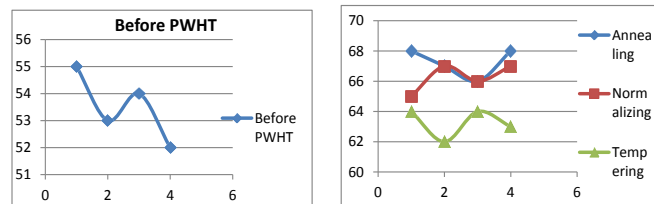


Figure 3: Impact strength for IS 2062 welded joint of before post weld heat treatment and after post weld heat treatment processes.

	Current (Amps)	Voltage (Volts)	Impact strength (J)			
			Before post weld heat treatment	After Annealing	After Normalizing	After Tempering
1	160	26	55	68	65	64
2	160	30	53	67	67	62
3	180	26	54	66	66	64
4	180	30	52	68	67	63

Table 3: Impact strength results for IS 2062 welded joint for before and after post weld heat treatment process.

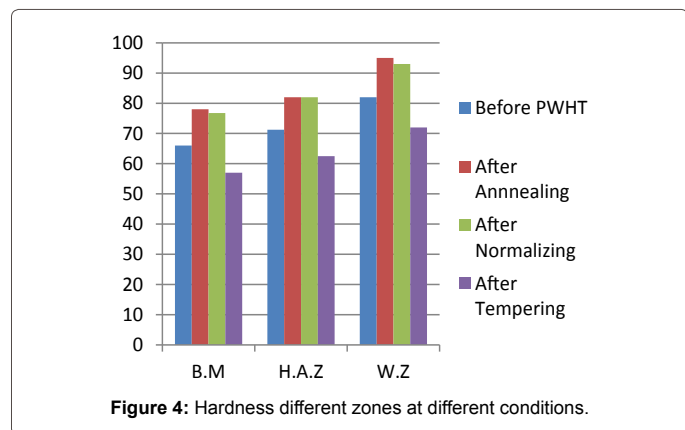


Figure 4: Hardness different zones at different conditions.

Hardness	Before post weld heat treatment	After Annealing	After Normalizing	After Tempering
B.M (IS 2062)	66	78	76.75	57
H.A.Z (IS 2062)	72	82	82	62.5
W.Z (IS 2062)	82	95	93	72

Table 4: Hardness at different locations in IS 2062 and IS 2062.

identify for industrial requirements. A practical standpoint, hardness measurements are quicker and more straightforward than numerical calculation of the HAZ. Especially at the welded zone of similar material is 15.85% is increases for the before heat treatment condition test samples (Figure 4 and Table 4).

Microstructure- a process methodology

Welding processes and the associated heating and cooling of edges of the similar plates leads to the development of different microstructures in different zones have been observed. For metallographic observation before post weld heat treatment and after post weld heat treatment specimens were etched with 4% nital for 20 s and consequently the microstructures of the base, weld and the heat affected zone were defined. Specimens were prepared for Electron Back Scattered Diffraction (EBSD) analysis using standard sample preparation method. A Zeiss 940SEM with a tungsten filament was used. The SEM device is coupled with automatic OIMTM (Orientation Imaging Microscopy) software. In this before post weld heat treatment similar metals are to be joined by using MIG processes. It may be seriously after the size and shape of the grains of which materials is composed with filler metals. Depending upon the welding processes the grains of the welded zone grow to larger size and sometimes destroyed stresses setup during the welding and cooling (Table 5).

Annealing process: In this Heat treatment processes the weldment is heated to above the recrystallization temperature ($>750^{\circ}\text{C}$) with the weldment the carbon content is varied with respect to the temperatures. The carbon can be dissolved in it to form a solid solution ferrite ($C = 0.006\%$) at room tempeture, this can be increased to the heating temperatures limits. The micro structure of IS2062 steel obtained with carbon content of 0.83% or less is normally grains of pearlite and ferrite in the base metals, HAZ and welded zone (Table 6).

Tempering: At low tempering temperatures (Approx. $80-200^{\circ}\text{C}$) a hexagonal close-packed carbide (called epsilon carbide) begins to form, and with this rejection of carbon the crystal structure of martensite changes ultimately from tetragonal to the body-centered cubic characteristic of ferrite. The second stage at about 200 to 300°C , depending upon the steel is characterized by transformation of the retained austenite to bainite. During third stage from 300 to 475°C (Approx) there is formation of Fe_3C (cementite) from epsilon carbide and Change from low-carbon martensite to cubic ferrite. From 450 to 705°C (Approx.) the cementite (Fe_3C) agglomerates and coalesces. The structure becomes an aggregate of ferrite with cementite in quite fine spheres, referred to as tempered martensite and tempered bainite.

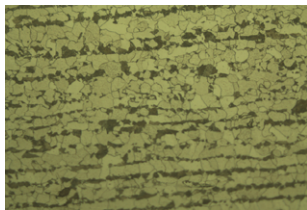
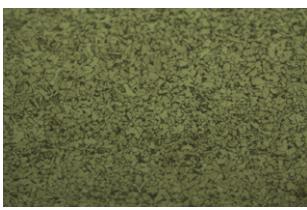
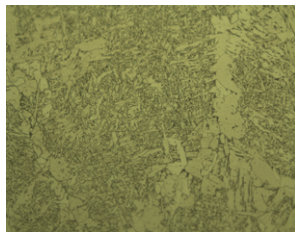
Record of Microstructure	Specimen name	Material	Condition
	ISO 2062 Gr.E250B	MS Plate	Before Heat Treatment
Heat Treatment	Description	Before Heat Treatment	
	Temperature (Max)	-	
	Temperature cooling (Min)	-	
	Soaking Time	-	
	Cooling Time	-	
Etchant Used	4% Nital		
Magnification	100X		
			
Parent Metal	HAZ	Wedment	
Result	The microstructure in parent metal consists of pearlite and ferrite, while the weld consists of coarse martensite.		

Table 5: Represents microstructure welding processing of grains of materials.

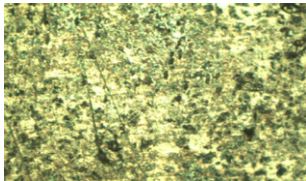
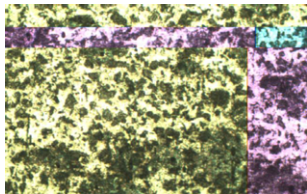
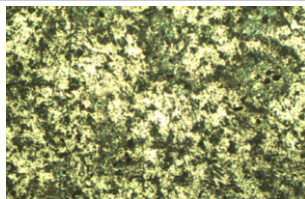
Record of Microstructure	Specimen name	Material	Condition
	ISO 2062 Gr.E250B	MS Plate	Annealing
Heat Treatment	Description	Annealing Heat Treatment	
	Temperature (Max)	750°C	
	Temperature cooling (Min)	200°C	
	Soaking Time	1 hr	
	Cooling Time	3 hrs	
Etchant Used	4% Nital		
Magnification	100X		
			
Parent Metal	HAZ	Weld Zone	
Result	The microstructure in parent metal consists of pearlite and ferrite, while the weld consists of martensite.		

Table 6: Represents microstructure of annealing processes.

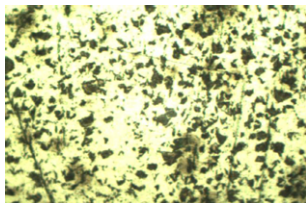
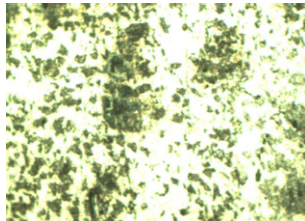
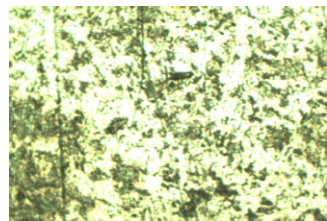
Record of Microstructure	Specimen name	Material	Condition
	ISO 2062 Gr.E250B	MS Plate	Tempered
Heat Treatment	Description	Tempered Heat Treatment	
	Temperature (Max)	705°C	
	Temperature cooling (Min)	200°C	
	Soaking Time	1 hour	
	Cooling Time	2 hrs	
Etchant Used	4% Nital		
Magnification	100X		
			
Parent Metal	HAZ	Weld Zone	
Result	The microstructure in parent metal consists of pearlite and ferrite, while the weld consists of fine tempered martensite.		

Table 7: Represents microstructure of tempering processes.

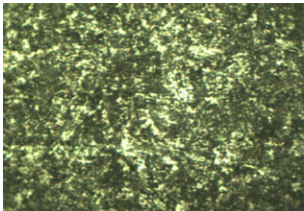
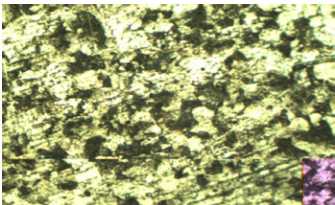
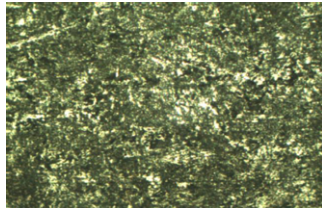
+Record of Microstructure	Specimen name	Material	Condition
	ISO 2062 Gr.E250B	MS Plate	Normalising
Heat Treatment	Description	Normalised Heat Treatment	
	Temperature (Max)	1100°C	
	Temperature cooling (Min)	200°C	
	Soaking Time	1 hour	
	Cooling Time	4 hrs	
Etchant Used	4% Nital		
Magnification	500X		
			
Base Metal	HAZ	Weldment	
Result	The microstructure in parent metal consists of pearlite and ferrite, while the weld consist of martensite.		

Table 8: Represents microstructure of normalizing processes.

The structure may become more or less uniformly spheroidized from prolonged heating at the upper end of the range (Table 7).

Normalizing: Normalizing or air quenching consists in heating steel to about 40-50°C above its upper critical temperature (i.e., A_3 and A_{cm} line) and, if necessary, holding it at that temperature for a short time and then cooling in still air at room temperature. The purpose of structure is obtained by normalizing largely depends on the thickness of cross section as this will affect the rate of cooling. Thin sections will give a much finer grain than thick sections. Normalizing produces microstructures consisting of ferrite (white network) and pearlite (dark areas) for hypoeutectoid (i.e., up to about 0.8% C) steels. For eutectoid steels, the microstructure is only pearlite and it is pearlite and cementite for hypereutectoid steels (Table 8).

Conclusions

In this work IS2062 of 10 mm thickness of the plate is used as single V-type grooved weldment. Optimal Post Weld Heat Treatment processes are used for the following annealing, normalizing and tempering condition. Tensile test, harpy-V test and hardness samples are evaluated from the IS2062 as compared to the before post weld heat treatment conditions. This work is effectively used to improve the properties of weldment by using optimal post weld heat treatment processes. Particularly in between HAZ and WZ some cracks are initiated, finally it's propagated during the preparation of the samples. These are observed in micro hardness examinations at different zones of weldment.

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