Effects of PWHT on the Hardness and Fractured Microstructure of IS-103Cr1 Welded Joint

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Abstract
During the welding process change of chemical and physical reactions due to the flow of heat in the weldments are varied with respect to rate of cooling time and weld axis. In the dissimilar welded joints, at the welded portion it can exist in more than one crystalline form and the carbon atom is only 1/30th size of the iron atom. The weldments are underlying their properties so to achieve the better results that are possible through heat treatment processes.

Keywords: Annealing; Tempering; Normalizing; Quenching; Hardness; Microstructure

Introduction
Firstly, the materials which are of the size (250 x 100 x 10 tk) mm are to be taken. Select the Universal milling machine for weld groove beveling and deburr the plates. Then fix the plates in the Machine wise or milling wise, then milling is done on both sides of the plates (i.e., 12 plates) by using T-max 80 φ cutter with speed of 450 rpm. For beveling we have to turn the facing head up to 30° and feed is given slowly. So the Edge Preparation is done to do welding as Single V butt joint. After Edge preparation we have select the combinations of material pair for further purpose. Here the Combination of the weld plates are selected in such a way that for the first joint low and medium carbon steel plates, for second joint low and high carbon steel plates, for third joint medium and high carbon steel plates are selected in a random manner. 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. Here we consider the MIG (Metal Inert Gas) Welding or Gas Metal Arc Welding (GMAW) whereas MIG wire (Copper Coated Mild Steel) with diameter 1.2 mm is taken [1-4]. The importance of copper coating on Mild steel is used to prevent rust and also current is passed easily [5]. Anti-spatter spray is sprayed on the wire for easy clean up after a flux core mig welder [6,7]. Then welding is done for 3 passes with respect to voltage, current and welding speed is considered after doing MIG welding for all the 6 joints we have to do back grinding in order to increase the tensile strength and then we have to conduct Dye Penetrant (DP) test in order to find out weld defects [8-10]. In this test we have to Pre clean the test surface in order to remove any dirt, paint, oil, grease or any loose scale that could either keep penetrant out of a defect, or cause irrelevant or false indications. Then, application of penetrant, where it is allowed "dwell time" to soak into any flaws. Next the application of developer where it draws penetrant from defects out onto the surface to form a visible indication. The test surface is often cleaned and we can record the defects. After welding, 3 joints (i.e., Before Heat treatment) are to be conducted Mechanical properties tests and the other 3 joints (i.e., After Heat treatment) are to be heat treated and then we can conduct Mechanical properties tests [11-13]. We have to doing pieces as per dimensions on Shearing Machine where the clearance between the top blade and lower blade is taken as 0.28 mm. Then grinding is done on Surface Grinding machine where the plates are placed on Electrical magnetic chuck and during grinding we use coolant as lubricating cutting oils, in order to prepare specimens (Table 1).

Annealing
This process is carried out in a controlled atmosphere of inert gas to avoid some oxidation. Here heating and cooling rates affect the mechanical and micro structural properties of similar and dissimilar weldments. The cooling rate very slows around 10-200°C and time taken 12 hrs. Normalizing: In this process the weldments (material) is heated above the austenitic phase and then cooled in air (1100°C) and time taken 2 hrs.

Tempering
In this process the material is heated below recristalization temperature (350-400°C) keeping it one or two hours and then cooled slowly at prescribed rate. Quenching: in this process a metal must be heated into austenitic crystal phase and then quickly cooled in different media. Here, sudden cooling of heated material to transform austenite to martensite and time taken 5 sec.

Olabi et al. [13], in this investigation work low carbon structural steel has been taken SAW process is used joint the two I-section component make an box weld component. After that evaluated mechanical properties, micro hardness, tensile strength and impact test have been employed on the welded joint under welded and after PWHT conditions. One of the most important significance observe in this work is to effect the PWHT to improve the toughness in about 15% reducing the residual stresses about 70% and slightly reduction in hardness variation, tensile strength. Prasad, Duivedi [14-17] was investigating "Investigations on microstructure and mechanical properties of sub merged arc welded HSLA stell joints." Welding current and speed (heat input) affects macrostructure of weld metal. Low heat input (3 KJ/mm) produced weld metal free from columnar grains. Increase in heat input coarsened the grain structure appreciably.

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and produced columnar dendrite in the weld metal. Microstructure study of all weldments revealed following regions: fine equiaxed grains near weld centerline, coarse columnar grain near the fusion boundary, coarse grained HAZ with thick acicular ferrite plates along the pearlite grain boundaries, fine ferrite and pearlite grains, partially refined ferrite and pearlite grains followed by coarse ferrite and pearlite grains of unaffected base metal. Increase in heat input coarsened the grain structure. Hardness variation across the weld centerline exhibited four different regions a) Largely uniform hardness in weld metal, b) Low hardness region near the weld fusion boundary, c) Gradual increase in hardness till maximum value from fusion boundary to grain refined zone, d) Sharply decreasing hardness from fine grained region through partially refined zone to base metal. The average hardness of both weld metal and HAZ decreased with increase in heat input. HAZ showed higher hardness than the weld metal.

Toughness of weld metal has been found a function of welding current and welding speed. Increase in welding current from 500 to 600 A increased the toughness appreciably at both welding speeds investigated followed by minor reduction with further increase in welding current from 600 to 700 A. Toughness was found higher at low welding speed (200 mm/min). The microstructure evolution of various HAZ regions during post weld heat treatment (PWHT) has been investigated and used to explain the toughness changes. A 760°C for 2 h PWHT can significantly increase the cross-weld toughness of the HAZ. The measured weld HAZ toughness can be understood using a linear additive model that employs as the inputs the toughness of the HAZ. The toughness of the CGHAZ recovers the slowest as a function of increasing PWHT temperature and remains low until a 730°C heat treatment. To guarantee an adequate HAZ toughness, a minimum tempering temperature for the base metal. The effect of post weld heat-treatments on mechanical properties and residual stresses mapping in welded structural steel, in this connection lot of work has been carried out the influences the welding parameters and PWHT on the mechanical properties, microstructural and residual stresses, composition of the filler metal deposition and welded joint geometry for the different welding process are used to make a welded joints under preheat condition. The specimens are investigates based on the following heat treatment processes (Table 2).

The CCT diagram explained each heat treatment process. Here carbon content is varied due to the microstructure of specimen was observed on optical microscopy (Figure 1). It is first appropriate to modified our abscissa since the x-axis is marked logarithmically t = 10⁻⁴. In a curve as we know the temperatures of each processes and taken on y-axis similarly on x-axis time we can measured on the basis of t = 10⁻¹, 12 × 60 sec = 10⁻¹, then x = 4.85 (Annealing process), x = 3.08 (normalizing), x = 1.69 sec (quenching). From experimental data the hardness valves are very high in the case of normalizing, because of the faster cooling of weldment microstructure was observed under a microscopy, the micro structure grains take a needle shape can be shown in the diagram. When a similar and dissimilar weldments are heated above recritilization temperature (725°C) cementite dissolves in the metal and new phase is formed when is called austenite. Here three phase involved in the weldments (ferrite, carbide, austenite).

From the graph quenching process is faster than the other Heat treatment process due to the faster cooling of grains are formed body centred cubic structure and martensite form a niddle shape under optical microscopy and SEM fractured microstructures (Figure 2).

**Conclusions**

The hardness of the joints has been experimentally investigated via measured. The as-MIG welded dissimilar joints have a significant scatter in hardness due to variations in the PWHT processes and grain growth variation in observed at weld metal, various HAZ regions, and the base metal. The hardness of various HAZ regions during PWHT has been investigated and used to explain hardness changes. Usually in the normalizing process, hardness shows a slight increase the same has been observed in above results. It was observed that normalizing is giving harder material than the Base metal. With reference to the above results an appropriate heat treatment procedure may be required to get uniform hardness. It was observed that normalizing is giving higher material than the base metal. It was observed that tempering is giving softer material than the base metal. Hence it is concluded that practical importance of unaffected base metal. The hardness of various HAZ regions during PWHT growth variation in observed at weld metal, various HAZ regions, and the base metal. The hardness of various HAZ regions during PWHT has been investigated and used to explain hardness changes. Usually in the normalizing process, hardness shows a slight increase the same has been observed here in the above results. It was observed that the hardness values in the WZ are higher than the Base metal. Usually tempering reduces the hardness the same has been observed in above results. Again it was observed that the hardness values in the WZ are higher than the Base metal. With reference to the above results an appropriate heat treatment procedure may be required to get uniform hardness. It was observed that normalizing is giving higher material than the base metal. It was observed that tempering is giving softer material than the base metal. Hence it is concluded that practical

| Type of HT | Time(sec) | ΔT(°C ) | ΔT/Δt (°C/sec) | Avg. Hardness |
|------------|-----------|---------|---------------|--------------|
| Anneling   | 86400     | 845     | 0.00978       | 98           |
| Normalizing| 1800      | 845     | 0.46944       | 92           |
| Tempering  | 30        | 845     | 28.1666       | 88           |
| Quenching  | 2         | 845     | 422.5         | 99           |

Table 2: Represents average hardness at different time.
applications requiring harder material needs to be normalized while applications those requiring softer material needs to be tempered.

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