Microstructure and Mechanical Characterization of Post Weld Heat Treated Thermite Welded Rails

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ABSTRACT

The aim of the present work was to analyze to effect of heat treatment with the properties of their thermite welded rails. The chemical composition of Rail steel was ascertained with the help of Baird emission spectrometer Two rail ends were kept 20mm apart with proper alignment and Pre-heated the rail ends (to about 1000°C) was required to help the poured molten metal in washing away the surface oxidation on the rail ends, as otherwise, the molten metal may chill and solidify immediately on coming in contact with cold rail ends, without washing off the surface oxidation.. In this process, the highly exothermic reaction between aluminum and iron oxides results in the production of molten steel which is poured into a mould around the gap to be welded. (Thermite welding was carried out.). Thermite welded rail steels were subjected to ultrasonic test to check the soundness of the weld. The heat treatment involved annealing was carried out at 820°C for 45 min and air cooling to room temperature (normalized condition). The specimens were cut in the transverse direction from Heat treated Thermite Welded Rails and prepared according to AWS D 1.1 standard. Specimens were subjected to tensile test, Impact test and results were tabulated and Microstructural analysis was carried out with the help of SEM.

INTRODUCTION

Continuously welded rails have been increasingly laid to simplify track maintenance and inspection, control noise and vibration and to ensure travel safety. Rail welded techniques are of the utmost importance for the laying of continuous welded rails. The studies were carried out at different regions of the weldment such as base material, weld metal and heat affected zone. To characterize the properties of the weldment and for identification of various phases, hardness studies were also carried out in detail. Microstructural analysis was also carried out to characterize the various regions of the weldment. Welded Joints are critical spots in rails because by their structural and mechanical characteristics they represent discontinuities in rails. Welded Joints are exposed to longitudinal forces and stresses. Because Thermite welded joints have microstructure of a cast metal. Heat treatment could improve ductility and toughness which are typically low in cast structures. Based on this, the aim of the present work was to analyze to effect of heat treatment with the properties of their thermite welded rails.

EXPERIMENTAL PROCEDURES

The chemical composition of rail steel ascertained with the help of Baird emission Spectrometers. Two ends of rails were kept 20mm apart with proper alignment. Here 5 parts of Iron oxide red powder and 3 parts aluminum powder ignited at high temperature. Highly exothermic reaction took place and released tremendous amounts of heat. Exothermic reaction in the crucible completed after 25 seconds separating slag from molten steel. Liquid steel poured down into the hardened sand mold and got a welded joint of rail. Welded joint of rail subjected ultrasonic inspection to ensure the soundness of the weld and the heat treated involved annealing was carried out at 820°C for 45mm and air cooling to room temperature. Different test specimens were prepared from heat treated thermite welded rails as per AWS D 1.1. Test coupons were subjected to mechanical tests and results were tabulated.

Tensile test : The universal testing machine essentially consists of two parts, the strainer or pulling device and arrangement to measure and register the load on a dial. A gradually increasing tensile load applied on specimen and the resulting extension of the specimen observed. The percentage Elongation is a measure of a ductility of the metal percentage to reduction in area is another measure of ductility that can be measured in tensile test.

Impact test : This test analysis the response of the material for resistance offered by the material to rapid build of stresses. . The equipment could deliver maximum Impact energy of 30 Kg/mm^2 and striking velocity was 5m/sec. The angle of drop was 140 degree. The specimen was placed in the anvil. Energy consumed in breaking was indicated on the dial of the testing machine. A charpy specimen of cross section of 10x10 mm and contains 45-degree notch, 2mm deep with a .25mm root radius as per AWS D1.1.

RESULT AND DISCUSSIONS

Tensile strength and percentage of elongation: After heat treatment, the ultimate tensile strength of thermite welded rail increases and also percentage of elongation increases. After heat treatment, the UTS and the % elongation were higher values due microstructure having the finer structure. The gage length of a tensile specimen encompasses the weld metal and the Heat affected zone, by measuring the local cross section, noticeable heterogeneity of plastic deformation. The most pronounced deformation was observed in the heat affected zone at the minimum point of hardness. However, failure occurred in the center of the weld metal with a local minimum of hardness.

The mechanical properties of thermite welded rail like tensile strength and percentage elongation are given in the following table

After heat treatment, Impact energy of thermite welded rail increased due to change in microstructure from coarse grain to fine grain. As compared with non heat treated thermite welded rails, a Charpy value indicates that greater ability to withstand impact deformation and a lower sensitivity to concentrations of stress. it is indicates significantly improvement in toughness by influence of microstructure.

Microstructural analysis was carried out with the help of SEM. Microstructure of Heat treated Thermite Welded Rails shows the finer grains ferrite-Pearlitic structure. Very thin cementite lamellar appear in the pearlite.

CONCLUSIONS

- ☐ Heat treatment changes the property of weldment from Brittle to ductile.
- ☐ Improves the properties like tensile strength and % Elongation (ductility) after heat treated welded rails.
- ☐ Changes in Microstructure from coarse grain to fine grain structure.
- ☐ Very wide heat affected zone.
- ☐ The failure of the rail ductile in nature.
- ☐ Fracture surface of heat treated joint is gray with fine grained.
- ☐ Heat treated condition, ductile fracture occurred after a larger plastic deformation proceeding the rupture.
- ☐ It has been found that heat treated of the welded joint improves mechanical properties.

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Sl. No.	Tensile Strength in Mpa	Average in Mpa	% Elongation in mm	Average in mm
1	694	701	12	11
2	699		10	
3	711		12	

Table 1 : Ultimate Tensile strength of Thermite welded Rail

S.No	Impact energy(J)
1	13
2	13
3	11

Table 2 : Impact Strength of Thermite welded Rail

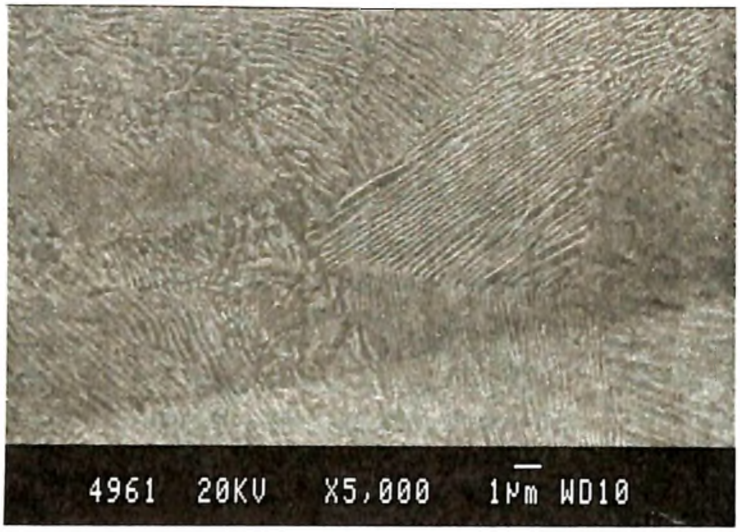

Figure 1 : Postweld heat treated Heat affected zone of Thermite welded Rail

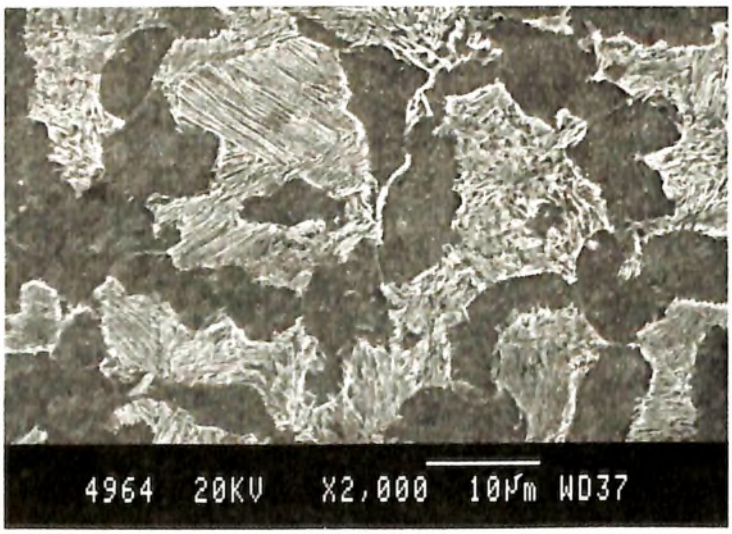

Figure 2 : Postweld heat treated Weldment of Thermite welded Rail