International Journal of Engineering Works
Kambohwell Publisher Enterprises
ISSN: 2409-2770 Vol. 5, Issue 5, PP. 116-119, May 2018
www.kwpublisher.com

To Study the Effects of Heat Treatment on the Welded Joints

Engr. Mujahid, Dr. Saim Saher, Engr. Zainab Huma

***Abstract*—** The present research was undertaken to demonstrate the effects of heat treatment on the welded joints. The material used was mild steel and aluminum. Ten flat tensile specimens, ten mounted specimens for micro structure test were prepared for steel and four flat tensile specimens, four mounted specimens for micro structure. This project is an effort to establish better understanding about the heat treatment of the welded joints. The scope of work includes the preparation of test specimens for tensile testing and micro structure analyses.

Keywords— Welding, Pre and Post welded joints, Grain size, Heat treatment, Universal testing machine, SEM, Machining.

I. INTRODUCTION

Fabricated structures often contain a number of welded sub-assemblies and these sub-assemblies generally contain several welded joints. The welded sections may require the Heat Treatment process to enhance the material properties. For tensile testing, from the first sample four set of specimens are prepared. One specimen is the original mild steel , second is "original heat treated" specimen, third sample is welded initially and then heat treated (pre-weld heat treated) and the other set of sample is heat treated initially and then welded (post-weld heat treated) . A comparison study is conducted on both types of specimens to evaluate the welding distortion and mechanical strength of the welded joints. Same procedure was repeated in the preparation of samples for the rest of two mild steel specimens and one Aluminum sample preparation.

For micro structure analyses, four set of samples are prepared for the first sample that is "original sample" "original heat treated sample" "pre weld heat treated sample" and "Post weld heat treated sample". Specimens for all the samples were prepared in the same fashion. After preparing the specimens, images of their micro structure are taken through scanning electron microscope (SEM).

A. Major Equipments Used

Heat Treatment Furnace: To perform the heat treatment on the selected and prepared specimen .one set of samples are "pre-weld heat treated" and other set of samples are "post-weld heat treated".

Scanning electron microscope: To take images from each of the mounted specimens to study the micro structure and to observe and analyze the effects of heat treatment on the grain size and structures of the specimens. Universal testing machine (UTM): To perform the tensile testing on different specimens and to study the effects of heat treatment on the tensile strength of the material selected.

Lathe machine: The Lathe machine of workshop section of University of Engineering and Technology Peshawar was used for the conversion of raw material into Dog bone specimens.

B. Material selection

We selected our material as "mild steel strip" and "aluminum bar". As these specimens are manufactured in the local industries of KPK so in order to find their exact composition we performed EDX analysis in CRL Lab University of Peshawar to find out there composition.

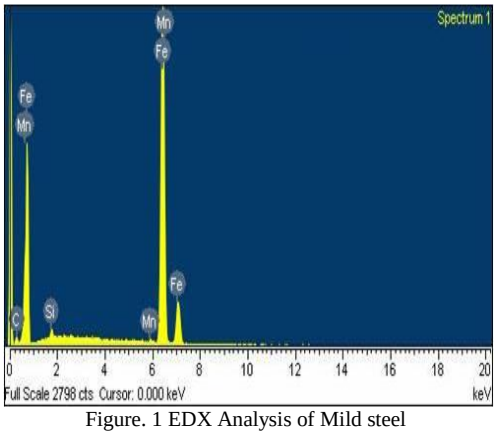

Figure. 1 EDX Analysis of Mild steel

From the results of EDX analysis we come to know about the composition of carbon which is above 0.8%. If the composition of carbon is above 0.8%, it is Hyper-Eutectoid so the metallurgical formulae are not applicable and we will examine its properties from the morphology of the structure i.e. SEM images. Now it becomes the base of our studies. This analysis has been shown in the Figure 1.

II. PREPARATION OF SPECIMEN

This section includes preparation of specimens for final tests and inspection .Two different sets of specimens were being prepared .They are:

A. Specimens for UTM

Engr Mujahid Wasim Durani: U.S Pakistan Center for Advanced Studies In Energy (U.S PCAS-E), UET Peshawar.

Dr. Saim Saher: U.S Pakistan Center for Advanced Studies In Energy (U.S PCAS-E), UET Peshawar.

Engr Zainab Huma: U.S Pakistan Center for Advanced Studies In Energy (U.S PCAS-E), UET Peshawar.

B. Specimens for microstructure analysis

In the following section we are going to describe the overall procedure employed in preparation of the specimens.

A. Specimen Preparation for UTM

First of all we take large strips of Mild steel. These large Mild steel strips were then cut into small pieces of strips respectively each having length of 14 inches. Each specimen was then machined in the "Machine shop" of workshop section of University of Engineering and technology Peshawar. Mild steel strips were then machined using Milling machine of workshop section. Where all these specimens were converted into Dog bone specimens. Each Dog bone specimen was having grip length of 3 inches on each side and gauge length of 8 inches. Three different sets of specimens were prepared comprising of 3 Mild steel sets of samples. These sets of samples were prepared for the purpose to have a set of samples for different heat treatment processes.

B. Specimen Preparation for Microstructure Analysis

A small part of mild steel strip was cut by using cutting machine of Metallurgy Lab, Department of Mechanical Engineering UET Peshawar. It was then mounted using "Mounting press " of the same lab and was coated in Bakelite. It was then polished in MRL Lab, Department of Physics, University of Peshawar in three phases.

In the first phase, it was rough polished on polishing wheels of P180, P240, and P320 grain size.In second phase intermediate polishing was done using polishing wheels of P400, P600 and P800 grain size.In third phase we go for fine polishing using P1200 grain size polishing wheel. Finally it was etched using specific etchant (3 parts HCL and one part HN03) and was studied in CRL Lab University of Peshawar for microstructure changes.

Different set of samples were prepared according to our requirement.

We prepared three sets of samples both for microstructure and UTM tests. They are:

- Mild Steel Strip Furnace cooled
- Mild Steel Strip Air cooled:
- Mild Steel Strip water cooled:

III. Results Obtained from UTM and SEM

A. Results Obtained From UTM

All the three specimens after preparing them in machine shop were carried to Metallurgy lab Department of Mechanical Engineering UET Peshawar where they were placed in furnace and were heat treated for 800°c & soaking time of one hour and were then furnace,Air and water cooled respectively. After executing all these steps these samples were carried to UTM Lab Department of Civil Engineering UET Peshawar where they were tested for improvement in Mechanical properties i.e. yield strength and ultimate tensile strength. The data obtained from UTM is tabulated in the below Table 1, 2 and 3 respectively.

TABLE I. Mild steel specimen furnace cooled

Specimen	Yield Strength	Ultimate Strength	ΔL
Original	7.04	10.08	1.5625
Original H.T	5.84	8.94	2.1875
Pre weld H.T	6.8	8.44	0.5625
Post weld H.T	5.34	5.72	0.1875

TABLE II. Mild Steel Strip Air cooled

Specimen	Yield strength	Ultimate strength	ΔL
Original	6.28	9.09	0.166
Original H.T	No	6.78	0.187
Pre weld H.T	5.94	7.49	0.250
Post H.T	6.45	8.56	0.375

TABLE III. Mild Steel Strip water cooled

Specimen	Yield strength	Ultimate strength	ΔL
Original	6.28	9.09	0.375
Original H.T	NO	10	0.125
Pre weld H.T	NO	7.18	0.062
Post H.T	5.63	7.60	0.187

B. Results Obtained from SEM Analysis

The results of SEM of all three pre welded specimens are given below.

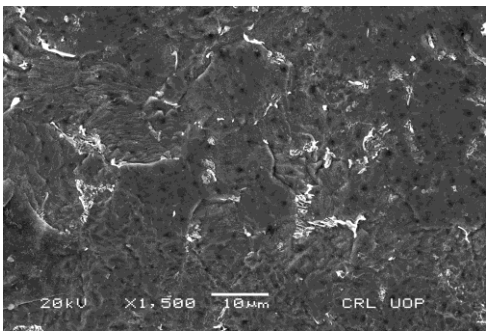

Figure .2 SEM of Pre-weld mild steel strip furnace cooled

ISSN: 2409-2770

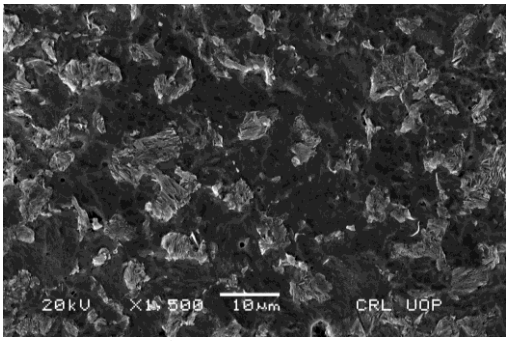

Figure .3 SEM of Pre-weld mild steel strip Air cooled

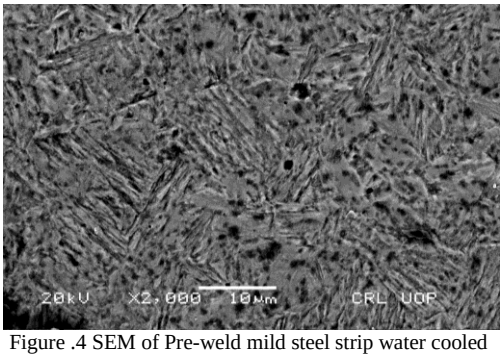

Figure .4 SEM of Pre-weld mild steel strip water cooled

IV. CONCLUSION

From the preceding tests and our research studies keeping in view the conditions and the type of heat treatment processes done on the specimen it is clear that if the amount of time provided and available for cooling, the microstructure will be having considerable changes respectively.

In case if we take the original specimen in each case it will be having good mechanical properties But in engineering designs, assembling and fabrication, the use flat part or piece of a material with no welded joints is not possible each and every time. It will definitely contain joints and welded parts, which is the objective of our research work to check for the changes in mechanical properties of welded joints i.e. Pre weld specimens and post weld specimens.

1) If we see the trend of mechanical properties i.e. Yield strength and Ultimate tensile strength in first specimen which is furnace cooled, they are both high in original specimen.

Upon going to the heat treated original sample, value of both of these properties decreases but change in length increases because in furnace cooling a lot of time was available for cooling and upon slow cooling in furnace the size of grain formed was small & fine and the cementite network showing weak zone becomes shallow because of heat treatment process, thus it is having high ductility compared to the original mild steel with no heat treatment. Now coming towards pre weld specimen, recall that it was the specimen that was first welded and then heat treated. Its Yield strength increases but its ductility goes down. It is due to the fact that welded joint can never be as strengthen as the original one and also if we pay attention to its morphology its grains are fine but the welding done on it (producing 10,000ºF temperature) distort its properties and thus it is having low ductility. The last one is Post welded joint in our first group of specimens. It is having decreased tensile strength, ductility and Ultimate tensile strength .It is because of the fact that this specimen was first heat treated at 800ºC and after cooling in furnace to room temperature it was then welded. The process of welding as earlier stated increases the temperature of heat affected zone to 10000ºF and was then allowed to be cooled in an open air. Hence not a slow cooling and the size of grain formed are large comparatively, thus this specimen is having smaller ductility and other mechanical properties compared to Pre-weld heat treated specimen.

2) If we see the trend of mechanical properties In the second group of specimens that were heat treated and then air cooled, we observe that the mechanical properties goes down up to the extent that no yield point is observed as a result of heat treatment in the original heat treated specimen. It is because of the fact that in the air cooling the heat treated specimen were not having slow cooling as in the air the temperature drops suddenly and the grains thus formed were not fine and the result is the decrease in mechanical properties such as yield strength ,ultimate tensile strength and ductility.

In the case of Pre-weld specimen the mechanical properties are improved as the cementite network is also shallow thus weak zones are small and the grain size formed is considerably small and the cementite network is also shallow thus it has high yield & ultimate tensile strength and ductility compared to original heat treated specimen In the Post weld heat treated specimen the grain formed are much fine and small thus it is having high mechanical properties at the cost of somewhat decreased ductility.

Based upon the findings of this research work it can be deduced that the choice of heat treatment dpends upon application and the working condition of welded joints to which it will be exposed .

V. ACKNOWLEDGMENT

The Author would like to thanks Dr. Saim Saher, who is also the supervisor of this paper, for his continued support, guiding and supervision throughout the preparation of this manuscript. The author would also like to thanks Engr. Zainab Huma for his untiring efforts and dedication in the testing of specimens and towards preparation of this text. In addition the author would thank staff and management of University of Peshawar, Pakistan where the preparation and testing of specimens actually takes place.

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Engr Mujahid Wasim Durani completed his Bachelor's degree In Mechanical Engineering from University of Engineering and Technology (UET) Peshawar,Pakistan in 2015. Presently, he is enrolled in Masters in Materials for Energy Storage and Conversion from U.S Pakistan Center for Advanced Studies In Energy (U.S PCAS-E), UET Peshawar. He has also been a research scholar at Arizona State University(ASU),USA. His area of interest includes heat treatment technologies, mechanical design, Li-ion batteries and SOFC fuel cell. Currently he is working in an aerospace industry in the role of mechanical design engineer and heat treatment specialist of aircraft parts.

Saim Saher is Assistant Professor of Materials for Energy Storage and Conversion at USPCAS-E UET Peshawar. He studied characterization and performance enhancement of SOFC materials during PhD research in University of Twente (Netherlands) , RWTH Aachen University (Germany) and University of Montpellier-II (France) funded by EUDIME EACEA-EU. Before, he had studied Aerospace Engineering from Seoul National University (SNU, South Korea) and graduated as M.Sc. Aerospace Engineering in 2010. He has served renown national and international organization such as NESCOM (Pakistan), UET Peshawar, Inorganic Membrane (IM) University of Twente (Netherlands), Samsung Electronics Co. Ltd. (South Korea) and Intelligent Control System Laboratory (SNU, South Korea).

Engr Zainab Huma received her Bachelor's degree In Electrical Engineering from University of Engineering and Technology (UET) Peshawar,Pakistan in 2015. She is currently doing her Masters of Science in Electrical Energy Systems Engineering from U.S Pakistan Center for Advanced Studies In Energy (U.S PCAS-E), UET Peshawar. She has also been a research scholar at Arizona State University(ASU),USA. Her area of interest includes electro-mechanical designing, heat treatment technologies rechargeable Li-ion batteries and solar renewable energy.

ISSN: 2409-2770