The Effect of Humidity Absorbed by Electrode Rods on Quality, Strength and Stiffness of the Weld

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Abstract

Inadequate storage for welding electrode rods might cause humidity absorption by these rods. Humidity effects directly and negatively on the weld quality. This paper is devoted to study such an effect on the quality, strength and stiffness of the weld. Some of Non Destructive Testing (NDT) and Destructive Testing (DT) were implemented on various samples of the same low carbon steel (AISI 1010) with same dimensions. These samples were cut into two pieces and joined by means of Metal Inert Gas welding (MIG) using dry and wet electrode rods separately. A comparison between these samples which were welded by dry electrode rods and wet electrode rods has been made. Unlike the samples which were welded by dry electrode rods, the obtained results of (NDT) showed obviously internal and external defects due to using such wet electrode rods. Meanwhile, (Tensile Testing) results demonstrated a decreasing in stiffness for the samples which were welded by wet electrode rods.

Keywords: welding electrode rods, humidity, weld quality, weld stiffness & strength, NDT, DT, MIG welding, low carbon steel, weld joint.

1. Introduction:

Welding is a fabrication or sculptural process that joins materials, usually metals or thermoplastics, by causing coalescence. This is often done by melting the work- pieces and adding a filler material to form a pool of molten material (the weld pool) that cools to become a strong joint.

Many different energy sources can be used for welding, including a gas flame, an electric arc, a laser, an electron beam, friction, and ultrasound. While often an industrial process, welding may be performed in many different environments, including open air, under water and in outer space [1]. Several manual welding techniques were developed to be Semi-automatic and automatic processes. These modern methods. are widely applied in industry such as gas metal arc welding, submerged arc welding, flux-cored arc welding and electro-slag welding [2]. Developments continued with the invention of laser beam welding, electron beam welding, electromagnetic pulse welding and friction stir welding in the latter half of the century. Today, the science continues to advance. Robot welding is common place in industrial settings, and researchers continue to develop new welding methods and gain greater understanding of weld quality. Various studies were conducted on different influences on the quality of steel weld joints such as researches in welding parameters represented in current, welding speed and voltage [5]. This work is devoted for another very important influence which is humidity.

2. Scope and Sequence of the Study:-

In this study, the effect of humidity due to improper storage of electrode rods on weld joint quality, strength and stiffness will be verified and assessed. Weld joint and relevant tests with both types DT & NDT will be demonstrated. The results of tests which are implemented on the samples will be showed and discussed. In this engineering problem, a sequence of solution procedure was applied. Figure 1. shows this sequence in general form.

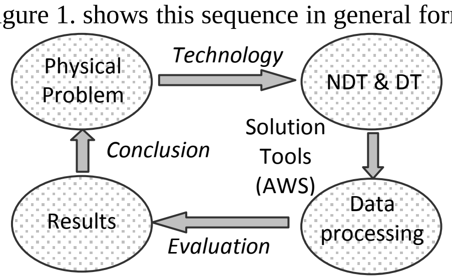

Figure .1 The solution sequence of engineering problem

3. PRACTICAL WORK & RESULTS:

The most common used DT & NDT tests were adopted for the weld joint samples of steel such as; penetrant test, metallurgy test, ultrasonic test and tensile test.

3.1 Preparation of samples:

Eight small carbon steel sheets were cut as a butt weld joint and welded by (MIG) welding method. The materials of electrode rods were of the same chemical composition of the base metal. Four of them were welded by using dry coated electrode rods and the others by using wet coated electrode rods. The rods were immersed into water basin for a period of ten minutes to guarantee a proper saturation.

3.2 Visual Inspection:

A visual inspection was done for both kinds of samples "welded by dry and wet electrodes" as shown in figure (2). The following visual defects were observed only on the samples which were welded by wet electrodes:

- Concave cap.
- Slag inclusion.
- Porosity "gas bubbles".
- Incomplete inclusion.

(a)

(b)

Figure 2. (a) Weld joint by dry electrode.
(b) Weld joint by wet electrode.

3.3 Penetrant test:

This type of NDT is very important as preliminary step to detect superficial defects which could be found in weld joints. This test contains components such as; cleaner, penetrant and developer.

3.3.1 Test procedures:

Firstly, weld joints of samples which were welded by dry and wet electrodes were perfectly cleaned by "cleaner". Weld joints were then sprayed by "Red colored Penetrant" and left for a period of time between "10-15 minutes" to be allowed to penetrate through the superficial flaws [2]. The samples were cleaned again but by using small quantity.

The weld joints were sprayed one more time by using "developer" up to cover whole the welded area with a white color. After a while, red colored areas were clearly revealed only on the weld joints which were welded by wet electrodes. Defects such as superficial cavities and flaws on the weld joints are shown in figure 3.

Figure 3. Penetrant test for the sample welded by wet electrode.

3.4 Metallurgy test:

For all test samples, a spectrophotometer device (X-MET5000) was used as shown in figure 4. The function of this device is basically constructed on x-ray, which is released on the sample to be tested. Based on x-ray absorption level of atoms, the materials and their compositions can be identified.

3.4.1 Test procedures:

1. The samples were cleaned properly.
2. The test device was positioned perpendicularly to the sample.
3. The device was operated and passed carefully on the sample.
4. The test was made on all samples and showed nearly the same compositions as shown in table 1.

Table 1. Relevant sample compositions

Material	Composition (%)
Fe	99.1
C	0.11
V	0.02
Cu	0.15
Ni	0.12
Mg	0.43
Mo	0.02
Cr	0.05

Figure 4. Metallurgy test by a spectro-photometer device (X-MET5000).

3.5 Ultrasonic test:
Ultrasonic test is one of the most and reliable non destructive tests in detecting internal defects for the materials [3]. Therefore, "USK 7S" ultrasonic device was chosen for this work as shown in figure 5.

Figure.5 Ultrasonic device "USK 7S"

3.5.1 Test procedures:

1. The relevant samples were cleaned and prepared properly as shown in figure 6.

(b)

Figure 6. (a) Weld joint by wet electrode, (b) Weld joint by dry electrode.

2. The suitable prob for each sample was selected as shown in figure 7.

Figure 7. Ultrasonic test prob.

3. Calibration for the prob was done by using calibration block which shown in figure 8.

Figure 8. Ultrasonic test prob calibration.

4. For easier maneuvering of the prob, greasing was applied on both weld joint and heat affected zone (HAZ) as shown in figure 9.

Figure 9. Greasing for the samples

5. The prob has been maneuvered near and parallel to weld joint for all samples and the results were obtained as follows:

i. The weld joints which were welded by dry electrode rods showed no internal defects as shown in figure10.

Figure 10. No signs on the screen

ii. The weld joints which were welded by wet electrode rods showed the following internal defects:

- Lack of penetration as shown in figure 11.

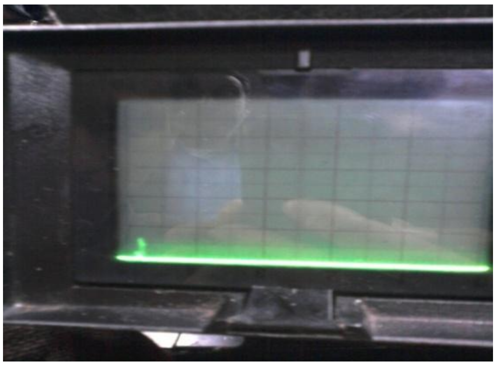

Figure 11. Lack of penetration for weld joint welded by wet electrode rods.

- Lack of fusion as shown in figure 12.

Figure 12. Lack of fusion for weld joints welded by wet electrode rods.

- Internal cracks as shown in figure 13.

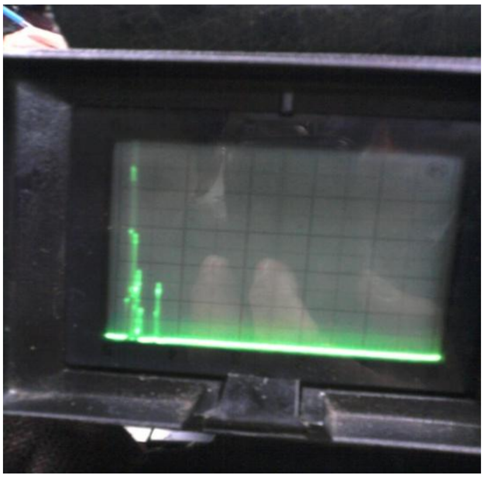

Figure 13. Internal cracks for weld joint welded by wet electrode rods.

3.6 Tensile Test:

Tensile testing is one of the fundamental destructive tests (DT) to measure the mechanical properties of material. Thanks to the clear, simple layout of the hydraulic **WP310 Universal Material Tester** as shown in figure 14. The device has the capability to observe all details and phases of the experimental procedure. Simple operation and a robust construction are also positive aspects for use in experiments [6].

In this way, material data and regularities can be verified using measurement data obtained by the operator and a wide range of experiments can be performed. Thus, the following concepts are actually obtained:

- Tensile strength.
- Elongation at fracture and reduction of area after fracture.
- Elastic and plastic deformation.
- Stress-strain curve.

Experiments of qualitative and quantitative nature can be performed on various materials and then results can be compared.

3.6.1 Test procedures:

All samples were prepared to be installed properly on the testing machine **WP310** as shown in figure 14.

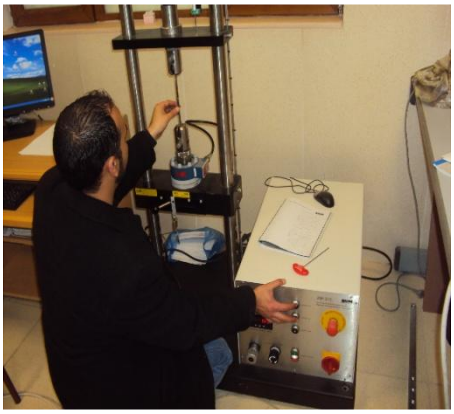

Figure 14. Tensile samples installation.

During tensile loading, both of the samples which were welded by dry electrode rods showed;
a maximum elongation of **(ΔL_1=34.49 mm)** for the first specimen and **(ΔL_2=34.89 mm)** for the second one as shown in:
Load - Elongation curves, figure 15. and figure 16. respectively.
The Stress – strain curve is illustrated in figure 17. for the first specimen and figure 18. for the second one.

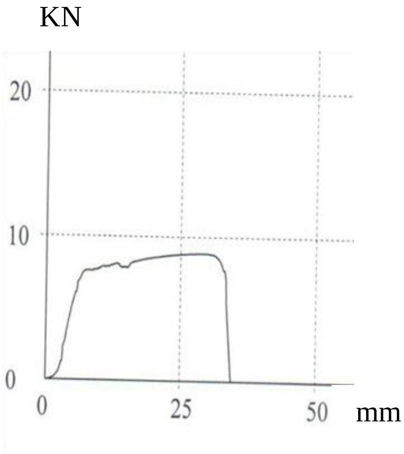

Figure 15. Load - Elongation curve for the first tensile specimen welded by using dry electrode rods.

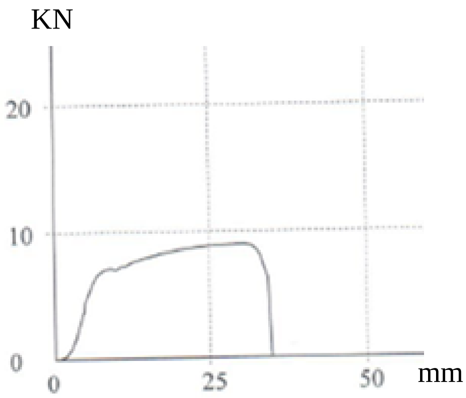

Figure 16. Load - Elongation curve for the second tensile specimen welded by using dry electrode rods.

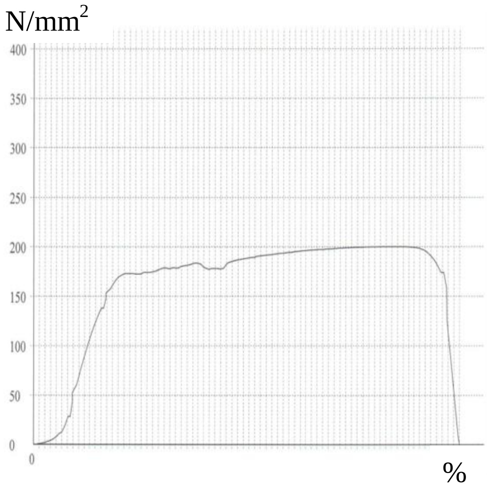

Figure 17. Stress - strain curve for the first tensile specimen welded by using dry electrode rods.

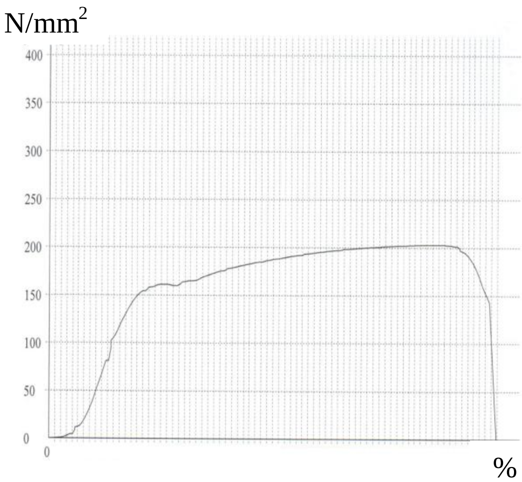

Figure 18. Stress - curve for the second tensile specimen welded by using dry electrode rods.

During tensile loading, both of the samples which were welded by wet electrode rods showed:
a maximum elongation of **(ΔL_1=45.27 mm)** for the first specimen and **(ΔL_2=38.73 mm)** for the second one as shown in Load - Elongation curves, figure 19. and figure 20. respectively. The Stress – strain curve is illustrated in figure 21. for the first specimen and figure 22. for the second one.

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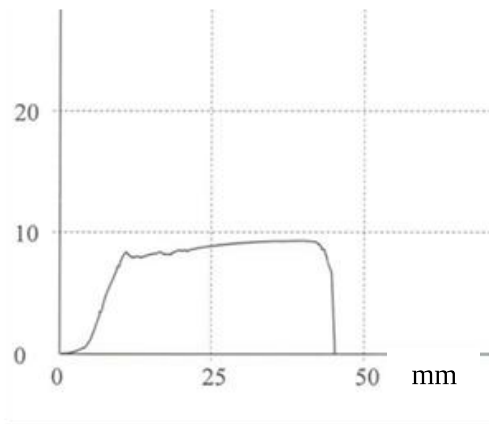

Figure 19. Load - Elongation curve for the first tensile specimen welded by using wet electrode rods.

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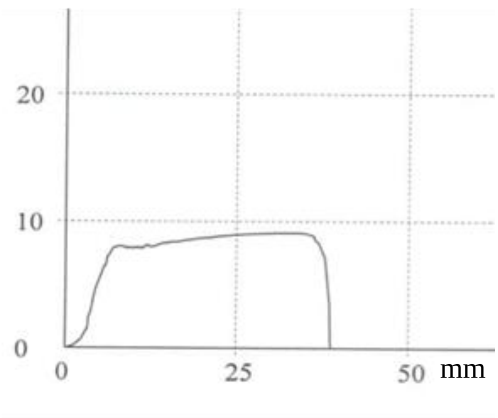

Figure 20. Load - Elongation curve for the second tensile specimen welded by using wet electrode rods.

N/mm^2

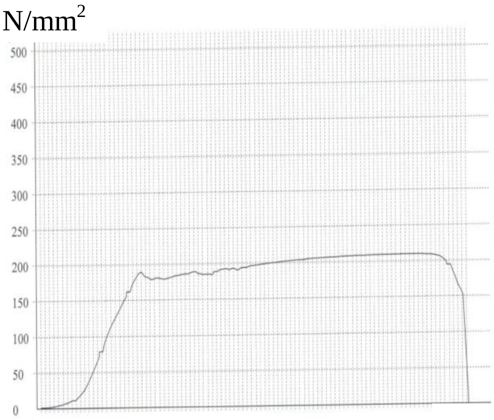

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Figure 21. Stress - Strain curve for the first tensile specimen welded by using wet electrode rods.

N/mm^2

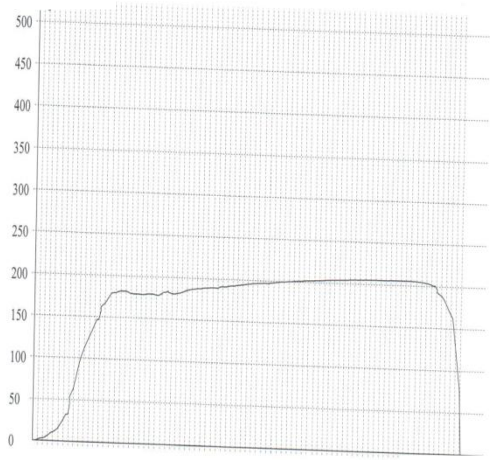

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Figure 22. Stress - Strain curve for the second tension sample welded by using wet electrode rods.

4. Conclusions:

From the presented results of this study the authors conclude the following:

1) According to metallurgy test, the chemical composition of all specimens are matching.
2) The weld joint of specimens which have been welded by dry electrode rods showed no visual defects and no internal defects.
3) Based on penetrant test, the weld joint of specimens which have been welded by wet electrode rods showed Concave cap, slag inclusion, porosity “gas bubbles” and incomplete inclusion.
4) Ultrasonic test showed lack of penetration, lack of fusion and internal cracks in the weld joint of specimens which have been welded by wet electrode rods.
5) The weld joint of specimens welded by wet electrode rods showed the same strength as the specimens welded by dry electrodes.
6) The weld joint of specimens welded by wet electrode rods showed low stiffness comparing with the specimens welded by dry electrode rods.
7) Humidity is one of the factors which causes decreasing in stiffness and reduces the quality of the weld joints.

5. References :-

1. ASME Boiler and Pressure Vessel Code, The American Society of Mechanical Engineers, 2007 edition.

2. AWS Standards, The American Welding Society, 550 Northwest Lejune Road, Miami, FL 33126, 2010 edition.

3. The American Society for Testing and Materials (ASTM), 100 Barr Harbor Drive, West Conshohocken, PA 19103, 2012 edition.

4. The American National Standards Institute (ANSI), 25 West 43rd Street, 4th Floor, New York, NY 10036, 2011 edition.

5. Study of influence of welding parameters on mild steel. International Advanced Research Journal in Science, Engineering and Technology, Vol. 2, Issue 5, May 2015.

6.WP310 Universal Material Tester. Manufactured by GUNT Company, Hamburg-Germany, 2009.