Analysis of Hardness of Material Connection of Weld on the Effect of Air Humidity

Kisman H. Mahmud, Sri Anastasia Yudistirani, Anwar Ilmar Ramadhan

Abstract: the mechanical properties of a welding construction depend on several factors such as air humidity during welding. A test is required to produce good quality and safety from a welding construction. From the tests performed on a welding construction, mild carbon steel material (soft carbon steel) is used. The welding is carried out by means of electrode welded electrode welding electrodes, with type E-7016 electrode type, flux-type low powder iron hydrogen, while different air humidity for each specimen, each of which: Test specimens I with air humidity + 50% ; Test specimen I with air humidity + 60%; Test specimen I with air humidity + 80%. It is known that the air humidity will raise the water content in the electrode, resulting in the decreasing of mechanical properties of welding construction. So to produce good quality and safety from the welding construction, it is necessary to have a large air humidity restriction or special subscription to the electrode to be used.

Index Terms: mechanical properties, air humidity, welded joints, moisture content

1 Introduction

One of the most important processes in the industry is the splicing of metals. This connection process is absolutely necessary because it is impossible to make the mold in the construction tool to fit the order request, although it can be seen that the mold requires a very high production cost. This process of metal grafting is mostly done in the factory environment, but many are also carried out outside the factory environment, as in many petroleum industries conducted outside the factory environment, such as in the highlands or lowlands, in the middle of the sea and so forth where the goods of course like this far different from the environment inside the factory [1]. The metal splicing process used today is welding with Shielded Metal Arc Welding (SMAW). Widespread use of welding technology, demands good quality welding results. The quality of welding results other than determined by the use of welding parameters, welding operators, is also determined by other factors, such as moisture air / moisture electrode in the welding process implemented [2]. Often wrong decisions occur because of simple problems, such as moisture on the electrode wrap. Manufacturers or factory store in general giving attention for storage of welding electrodes in a dry place. In fact many of the welders do not heed that it is not too important to note [3]. This will result in the absorption of hydrogen absorbed by water and organic matter contained in flux or air humidity. This will lead to elaborate weld metallurgical changes, deformations, thermal stresses, and cracks, which will ultimately affect the mechanical properties and construction of the weld itself.

- *Department of Mechanical Engineering, Faculty of Engineering, Universitas Muhammadiyah Jakarta*
- *Department of Chemical Engineering, Faculty of Engineering, Universitas Muhammadiyah Jakarta*
- *Department of Mechanical Engineering, Faculty of Engineering, Universitas Muhammadiyah Jakarta*
  Email: anwar.ilmar@ftumj.ac.id

2 Literature Study

2.1 Shielded Metal Arc Welding

Arc welding with electrodes wrapped is the most widely used type of welding process today, in contrast to the carbon arc welding, where the electrodes do not melt, in the welding with the electrodes wrapped, the electrodes themselves are also attractive as fillers (filler metals), see Figure 1.

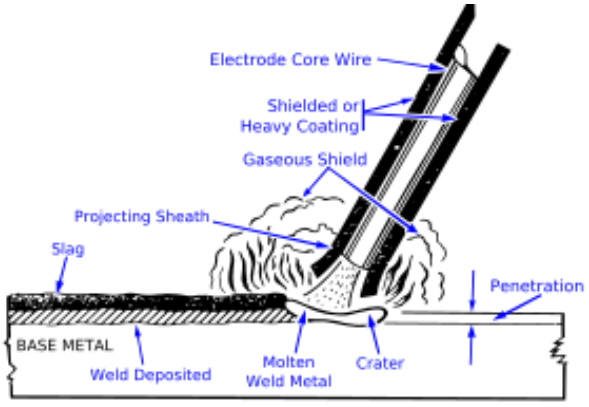

Figure 1. *Shielded Metal Arc Welding [4]*

The process of moving from the electrode to the parent metal occurs when the electrode tip melts and forms the grains carried by the electric arc current, therefore the magnitude of the current used greatly affects the size of the molten metal grain, for small currents, usually grain size large, while at high currents the grains become smoother.

2.2 Weld-ability

Weld-ability or welding is a measure that states the degree of difficulty of a metal to weld, whether the weld connection can satisfy whether the resulting construction can meet the desired objectives. The degree of difficulty of a metal to be welded can also be seen in terms of welding procedures, whether the metal requires special treatments such as ordering or not from the position of welding, whether the metal can be welded to all positions or specific positions only. If a metal requires special treatment before and after welding, the metal weld-ability is decreased. There are four (4) main issues that must be considered at the time of welding related to the properties of

weld-ability, namely:
1. Planning of structures, machinery and equipment to be welded.
2. The properties of the material or material to be welded
3. Processes, Procedures and equipment to be applied at weld time.
4. Weld quality inspection results.

2.3 Heat Effected Zone (HAZ)

Heat Effected Zone or HAZ are some of the parent metal that undergoes micro structure changes due to heat effect. The types of phase or microstructure produced in the HAZ area depend on [5]:
1. Carbon content
2. The content of alloying elements
3. The increase in temperature and cooling rate.

While the width of the narrow area of HAZ is influenced by [6]:
1. Metal geometry to be welded (thick and thin)
2. Welded metal type
3. Number of fills (single multi pass)

3 RESEARCH METHOD

3.1. Test Material

In this test the material used is (Figure 2): Material specification: Materials Testing: Soft Carbon Steel (Mild Carbon Steel)

Thickness: 12.7 mm
Width: 60 mm
Chemical Composition:
C = 0.18%; S = 0.32%; M = 0.80%; P = 0.008%; S =: 0.0027%; C = 0.0018%; M = 0.05%

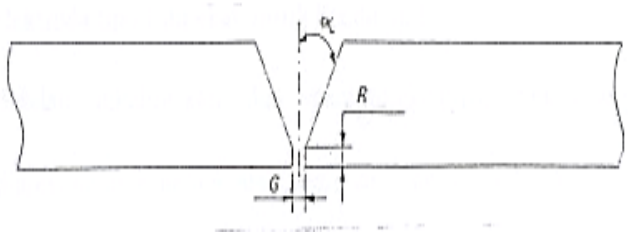

Figure 2. *Las and wire connections dimensions*

Where:
α = Angle groove angle = 30 +
R = Welded root legs = 1.6 mm + 0.3 mm
G = root gap = 3.2 mm

3.2. Welding Specimen

With use equation (1) and (2):

$$Q = \frac{60.E.I}{V}\frac{Joule}{cm} \quad (1)$$

Where:
E = Voltage (Volt)
I = Strong Flow Las (Ampere)
V = Welding speed (cm / min)

And,

$$Q = \frac{Q_1 + Q_2 + Q_3 + Q_4}{4} \quad (2)$$

Obtained for average price of heat input for each specimen, see Table 1.

Table 1. *The average price of heat input for each specimen*

Test Specimen Type	Heat Input (Joule/cm)
I	18572.50
II	21734.37
III	25326.77

From the heat input graph vs the influence of air humidity, it appears that the heat input increases with the increase of air humidity during welding or in other words the higher the air humidity, the greater the required heat input. This will result in decreasing the mechanical properties of tensile welds, meaning the quality of the welding results from the welding construction will be reduced. On the other hand a welding construction demands a good quality of welding results, in order to provide security against the construction of the weld itself.

3.3. Hardness Test

In general, hardness denotes resistance to deformation, and for metals with such properties are their resistance to plastic deformation or permanent deformation. Still others perceive violence as a measure of resistance to curvatures [7]. There are 3 types of hardness measurement, depending on how the measurement is done, namely:
1. How to move (Scotch Hardness)
2. Method of indentation (collision) consisting of
a) Brinell Method
b) Vickers Method
c) Rockwell Method
3. How to bounce (dynamic hardness)

4 RESULTS AND DISCUSSION

4.1. Measurement of Moisture Electrodes

The results of testing the influence of moisture from several test variations can be seen in Table 2-4.

Table 2. *Type I electrode*

Electrode	Water content (%)	Remarks
1	0	Electrode in the oven for + 2 hours at a temperature of 200 C
2	0.10	
3	0	

Table 3. *Type II electrode*

Electrode	Water content (%)	Remarks
1	0.20	Electrode is left for 4 hours at 60% humidity
2	0.20	
3	0.30	

Table 4. *Type III electrode*

Electrode	Water content (%)	Remarks
1	0.40	Electrode is left for 4 hours at 80% humidity
2	0.40	
3	0.35	

Table 2-4 shows that the air humidity of the electrodes in each sample has a great value as the addition of moisture from the weld conditions.

4.2. Measurement of welding

The results of testing the influence of moisture from several test variations can be seen in Table 5-7.

Table 5. *Data of welded product for Test Material I (standard)*

Number Layer	Diameter of Electrode (mm)	Current (Ampere)	Voltage (Volt)	Speed of Weld (cm/men)
1	3,2	90	25	8.67
2	3,2	120	25	8.93
3	3,2	120	25	9.12
4	3,2	120	25	9.56

Table 6. *Data of welded product for Test Material II (Humidity of 60%)*

Number Layer	Diameter of Electrode (mm)	Current (Ampere)	Voltage (Volt)	Speed of Weld (cm/men)
1	3,2	90	25	7.70
2	3,2	120	25	7.91
3	3,2	120	25	7.32
4	3,2	120	25	8.16

Table 7. *Data of welded product for Test Material III (Humidity of 80%)*

Number Layer	Diameter of Electrode (mm)	Current (Ampere)	Voltage (Volt)	Speed of Weld (cm/men)
1	3,2	90	25	7.54
2	3,2	120	25	6.87
3	3,2	120	25	5.56
4	3,2	120	25	7.25

It can be seen in Table 5-7 that the standard conditions have slower weld speeds compared to 60% and 80% humidity.

4.3. Hardness Test

The test results on the hardness test can be seen in Table 8.

Table 8. *Hardness Test Result Data*

Sample I			Sample II			Sample III		
Track number	d_1 (μm)	d_2 (μm)	Track number	d_1 (μm)	d_2 (μm)	Track number	d_1 (μm)	d_2 (μm)
1	82.9	79.3	1	74.2	76.0	1	79.1	80.3
2	81.3	80.8	2	77.0	80.6	2	78.6	77.4
3	82.4	80.5	3	72.7	75.7	3	76.8	78.2
4	78.8	78.8	4	68.3	69.7	4	76.4	75.4
5	72.5	72.5	5	70.4	70.0	5	69.8	66.8
6	67.8	70.0	6	70.3	69.4	6	69.4	72.7
7	68.1	68.5	7	68.6	70.1	7	69.5	69.8
8	68.2	69.9	8	70.6	73.2	8	66.2	66.1
9	70.2	71.5	9	70.7	72.2	9	67.2	68.6
10	74.3	71.5	10	75.8	75.8	10	72.2	73.0
11	64.3	74.3	11	81.9	78.6	11	79.2	83.6
12	50.3	63.6	12	83.4	80.4	12	79.1	81.3
13	77.9	53.8	13	74.9	82.1	13	78.8	78.5
14	75.5	77.9	14	79.9	76.6	14	79.1	75.5
15	73.6	76.2	15	73.3	71.1	15	70.9	71.4
16	73.5	73.6	16	76.6	76.5	16	69.9	71.4
17	75.0	74.9	17	77.3	72.7	17	70.8	70.3
18	73.2	75.2	18	87.0	81.6	18	73.3	78.6
19	79.2	73.6	19	79.3	75.9	19	78.7	78.7
20	78.2	74.9	20	80.2	76.2	20	76.3	73.7
21	77.8	89.0	21	75.7	77.8	21	74.2	70.4
22	75.4	76.9	22	79.4	72.4	22	82.4	77.2
23	75.4	79.3	23	77.5	74.4	23	84.7	75.5
24	76.6	76.4	24	84.2	74.5	24	77.4	74.6
25	75.9	75.4	25	80.9	74.6	25	76.4	73.9
26	72.4	79.3	26	80.4	80.4	26	84.5	78.1
27	77.6	75.4	27	80.9	78.8	27	77.7	74.2
28	78.9	78.0	28	80.6	76.4	28	74.9	74.3

Based on Table 8 shows the hardness values of each sample test i.e. Sample I has the smallest hardness value of 50.3, and has the largest hardness value 82.9. Sample II has the smallest value of 69.4 and the largest value 83.4. Sample III has the smallest hardness value is 69.8 and the largest is 83.6. This indicates that from each sample proves the effect of air humidity on hardness value.

5 Conclusion

From the tests carried out looking at the results of the test, it can be deduced that the clarity at the time of high humidity will cause:

1. The occurrence of defects in welding results
2. The ability of the welded connection to the curved load will decrease.
3. Decrease in the price of material hardness
4. Increased grain size in hot / HAZ heat extraction areas and welding deposit areas.

It is generally found that by the level of air humidity at the time of welding will decrease the mechanical properties of the material, this means affecting the quality and safety of welding construction.

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