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Production and Weld Joint Performance Evaluation of Locally Produced Arc Welding Electrodes as compared to Imported Ones.

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A B S T R A C T

The need to seek alternative means of conserving foreign exchange, tapping and utilizing our natural resources as well as developing Nigeria's technological base prompted the research into the production of Electrode locally and comparing it with other internationally established brands. The foreign electrode selected for this research is the "Oerlikon Brand". Iron based electrode was produced using locally sourced mill scales with predominantly iron oxide which is an important constituent in electrode coating. Sodium silicate was used as a binder to the flux composition. The electrodes were manually produced in a wooden mould. The electrode was used to weld three joints using three different welding methods on mild steel materials. The same was repeated using the Oerlikon electrode. The weld joints were subjected to tensile, hardness, and impact tests. The result shows that the Oerlikon electrode gave a tensile and hardness test of 453N/mm^2 and 457.1N respectively with 94.9joules as the maximum impact energy. The locally produced electrode result showed a tensile and hardness test of 403N/mm^2 and 432.1N respectively with 90.2joules as the maximum impact energy. This analysis showed high potentials for the locally produced electrodes and with a little improvement in the quality of the flux produced, it can compete favourably with the imported Oerlikon thereby help in conserving foreign exchange and contributing to technological growth.

Keywords: Oerlikon, Sodium silicate, mill scales, iron oxide, flux.

1.0 Introduction

Electrodes were developed thousands of years ago (Ahmed Y. M. et al., 2014). They are essentially iron coated with flux used with the aid of electric welding machine to join metals by generating an arc of molten filler metal deposited on the weld area (Cary H. B. 1998). There are two main types of electrodes, the consumable and non-consumable electrodes (Jeffus L. 2012). These electrodes are identified as carbon, bare, and flux coated electrodes and comes in standard sizes of between 350-450mm length. Their thickness determines the current to be used during the weld which increases with the wire diameter.

The electrode has two basic functions. The core wire which melts faster conducts electricity while the flux prevents oxidation and guides the deposit of molten electrode on the weld area.

History of Welding Electrodes

Between 1920s to 1930s, electrodes were developed in order to enhance metal joining processes. The demand for consumable electrodes grew with massive industrialization across the world and Nigeria is not an exception.

According to Volza's Nigeria import data, about 78 Electrode shipment running into Millions of USD was brought into Nigeria in September, 2024 alone. This import has a significant strain on the nation's economy. There is therefore the need to explore the possibility of locally producing mild steel consumable electrodes using available mill scales which is found in abundance form the steel rolling mills around. This research aims to compare and evaluate the performance of this locally produced electrode against an established brand (Oerlikon).

2.0 Materials and Methods

2.1 Materials:

1. Base Metal used mild Steel because of its availability and affordability.

2. Filler Metals: Electrodes and wires used in welding process on Manual Metal Arc Welding (MMAW).

2.2 Methods:

1. Tensile Testing: This was used to measure the strength and ductility of the weld joint.

2. Impact Testing: The impact test was used to evaluate the toughness of the weld using Charpy.

3. Hardness Testing: This was used to assess the hardness distribution across the weld, heat-affected zone (HAZ), and base metal.

4. Corrosion Testing: Was done to evaluate the resistance of the weld to corrosion, especially for materials used in harsh tropical environment around Nigeria.

Results

2.3 Tension test

One of the most important tests to be conducted on a weld joint is the tensile test. This is a crucial step in evaluating the mechanical properties and quality of the weld.

The weld joint samples specimens were prepared in line with relevant ISO standards ISO 6892-1. The specimen had a defined gauge length of 2mm thick and was machined to dimensions.

The weld joint selected for the research is of the lap weld with very smooth surface finish free from defects.

A universal testing machine (UTM) with sufficient capacity was used to test the specimen by gripping the specimen securely in the UTM by ensuring proper alignment and minimal bending or torsion. Test parameters, the following criteria were used; crosshead speed, gauge length, normal room temperature.

The load was applied gradually by increasing tensile load to the specimen until failure occurred. I the recorded the data.

I examined the fracture surface and observed the failure mode as ductile. I analyzed the stress-strain curve and evaluated the following weld joint's mechanical properties: Ultimate tensile strength (UTS), Yield strength, elongation at break, and reduction in area.

Table 1 Tensile Test

Type of Test/ Electrode	*Oerlikon*	*Local electrode*
Guage length	*25mm*	*25mm*
Specimen size	*50mm^2*	*100mm^2*
Type of weld joint	*Butt weld*	*Butt weld*
Ultimate Tensile Strength	*10MPa*	*5MPa*
Yield strength	*350MPa*	*300MPa*
Elongation at brake	*5mm*	*3mm*
Reduction in Area	*4mm*	*2mm*
Maximum load	*25000N*	*25000N*

Impact test was also conducted on the weld joint to evaluate its toughness and resistance to impact loading. The sample was prepared according to ISO 148-1. The specimen was made with a V-notch with dimensions that meet the standard requirements, including the notch geometry and location.

I used a pendulum impact testing machine for Izod test by placing the specimen in the testing machine, ensuring proper alignment and secured clamping. The following test parameters: Impact energy, pendulum height, and test temperature were used. The pendulum was released and allowed to strike the specimen and absorb energy. The energy absorbed by the specimen during impact was measured.

Table 2 Impact Test

	Oerlikon	Local electrode
Impact energy	1.5kj	1.2kj
Pendulum height	1.2m	1.2m
Test temperature	32ºC	32ºC

The weld joint specimen was prepared by cutting and polishing the surface to ensuring a flat and smooth finish.

Brinell hardness tester indentation was applied to the indenter, creating an indentation on the specimen surface. Brinell Hardness Test was used to measures the hardness based on indentation diameter.

Table 3 Hardness Test

	Oerlikon	Local electrode
Indentation diameter	0.15mm	0.15mm

The last test to be carried out was the corrosion test on the weld joint. This is crucial to evaluate its resistance to corrosion and ensure the integrity of the material. The specimen was prepared by cutting and polishing the surface to ensure it is flat and smooth.

Table 4 Corrosion test

	Oerlikon	Local electrode
Pitting	0.002mm/yr	0.004mm/yr
Crevice Corrosion	0.0001mm/yr	0.0002mm/yr
Weight loss of specimen	0.0025g	0.0027g

Pitting is calculated by: d=k*t^n

Where d=pit depth

K=corrosion rate constant

t=exposure time

n=exponent

Salt spray test (ASTM B117) was the method used for the test. The test environment was prepared, including the corrosive solution, temperature, and humidity and the exposure time was two hours which was monitored by visual inspection.

A visual Inspection was undertaken to examine the specimen's surface for signs of corrosion, such as pitting, crevice corrosion, or uniform corrosion. We measured the weight loss of the specimen, which indicated the extent of corrosion. The corrosion rate for the Oerlikon welded joint was measured in unit mm/year. We conducted an immersion Test to evaluate the resistance to corrosion in a liquid environment.

3.0 Results for the test

(a) Tensile Strength for Oerlikon electrode=Maximum load/Original Cross sectional area

Tensile strength for Oerlikon electrode=25000/50

=500MPa

Tensile Strength for locally produced electrode=Maximum load/Original Cross sectional area

Tensile strength for locally produced electrode =25000/100

=250MPa

(b) Impact energy absorbed on Oerlikon electrode = 520j

Impact energy absorbed on locally produced electrode = 470j

(c) Hardness tested on Oerlikon electrode=195HB

Hardness tested on locally produced electrode=190HB

4.0 Discussion

From all the tests conducted, the result shows a higher tensile strength for the Oerlikon electrode as compared to the locally produced one, this is obviously as a result of the impurities in the flux material of the locally produced electrodes.

The Impact and hardness tests result also shows a comparative advantage of using the Oerlikon electrodes. However, once those impurities are reduced to the barest minimum, the locally produced electrode will be able to meet up with the imported Oerlikon electrodes.

5.0 Conclusion

The local production of welding electrodes in Nigeria shows a very great prospect in view of the availability of raw materials and the big market potentials within and outside the country. This will also enhance technological growth and development of the Country.

6.0 Recommendation

I wish to recommend that more research be carried out on the use of local raw materials for the production of electrodes in order to conserve foreign exchange.

The impurities in the flux materials should be further reduced in order to enhance the quality of the weld joint.

More regulations should be made to encourage local production of electrodes in Nigeria.

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