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LOCAL SOURCING OF RAW MATERIALS FOR THE MANUFACTURE OF MANUAL METAL ARC WELDING ELECTRODES: A CASE FOR LOCALLY PRODUCED STEEL WIRE IN NIGERIA

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ABSTRACT

Since early 1995 when pressure was mounted on the Raw Materials Research and Development Council in Nigeria, with a view to sourcing wire, flux and binder locally, little or no success has been recorded. As at 1998, all the raw materials including core wire for electrode manufacture in Nigeria were still being imported. The aim of this project is therefore fo explore the possibility of using locally sourced wire in electrode production. In this research, wire drawn at the Oshogho rolling company in south western Nigeria from billets produced at Delta Steel Company Aladja in Delta state, Nigeria was used with commercial flux in a production run by a local electrode-manufacturing outfit. Mechanical tests and microstructure show that the quality of electrodes produced compared favourably with E6010 standards.

Keywords:* *Electrode Manufacture, Core Wire, Flux, Silicate Binder

INTRODUCTION

There have been various welding flux systems that eventually formed the basis for commercial welding electrodes. These include MnO-SiO2-CaO, SiO2-MnO-FeO and SiO-MnO-CaO-CaF2 flux systems [Janzen, 1977, Quigley, 1977]. Flux can affect arc stability by containing materials of various ionization potentials that will affect the number of electrons or ions present in the arc plasma at a given voltage. Materials which are added to the flux to produce vapour atoms with low ionization potential are classified as arc stabilizers [Morgan, 1976]. Hazlett found using pure single component compounds that CaO produces a more stable arc than either SiO2 or MnO. MnO, FeO, NiO, CuO and TiO2 were found to produce vapours that have a medium ionization potential and therefore have little effect on arc stability [Janzen, 1977].

Core wire

The earliest electrodes for arc welding were solid and bare, usually in the length of 300 – 350mm. Later on, solid wire was provided in coils for bare wire automatic arc welding and for submerged arc electroslag welding. The latest process to use solid bare wire is gas metal arc welding, which uses relatively small diameter electrodes [Cary, 1979]. The manufacture of wire for welding electrodes or rod is essentially the same except that the "straighten and cut" operation is added for a welding rod. The wire is drawn using various dies and drawing lubricants. Some wires are provided with a thin coating of copper to improve current pick-up and prevent rusting when exposed to the atmosphere. When the wire is cut and straightened, it is called a welding rod. If the wire is used in the electrical circuit, it is called a welding electrode. For more than five years now local welding electrode manufacturers have been groaning under unfavourable tariff on imported components [Okeke, 1998]. Capacity utilization for electrode manufacturer in Nigeria was about 5% in 1998 [Oyawale and Ibhadode, 2004].

The composition requested by local electrode manuacturers is as follows :

C = 0.010%	Mn = 0.40 – 0.60	Si = 0.02% max
P = 0.03% max	S = 0.003%	N = 0.012% max

This quality of mild steel can only be produced by the ingot method in which the almost pure skin of the rimmed steel is welded and rolled into rods which are then drawn into solid wires. The method of producing steel presently in Nigeria is by the Direct reduction (DR) process. The major steel plant in Nigeria (Delta Steel Company, Aladja) which uses the DR process is unable to reduce the carbon and silicon contents of its products to this level. In addition, aluminium which was used to kill the steel produced in Aladja posed additional difficulties. Unfortunately, the Ajaokuta steel Company which was expected to produce iron by the blast furnace method has not been able to produce. The objective of this paper therefore is to explore the possibility of using the Nigerian wire as core wire for electrodes manufacture.

Materials and Method

Wire drawn from rods rolled from the billets produced at the Delta Steel Company Aladja have the composition shown in table 1.

Table 1. Oshogbo Roling Mill: Chemical Composition of Rolled Billets

Billet qualities	C	Si	Mn	Ph (max)	S (max)	Cu (max)	Cr (max)	N (max)	Sn (max)
NST-34-LC	0.06-0.12	0.14-0.28	0.40	0.60	0.044	0.25	0.10	0.011	0.05

The flux used for the coating was the regular commercial flux used by Induweld – a local manufacturing outfit in Lagos Nigeria. The electrodes were produced by the same company, coating the wire in a continuous process as shown in Fig. 2.

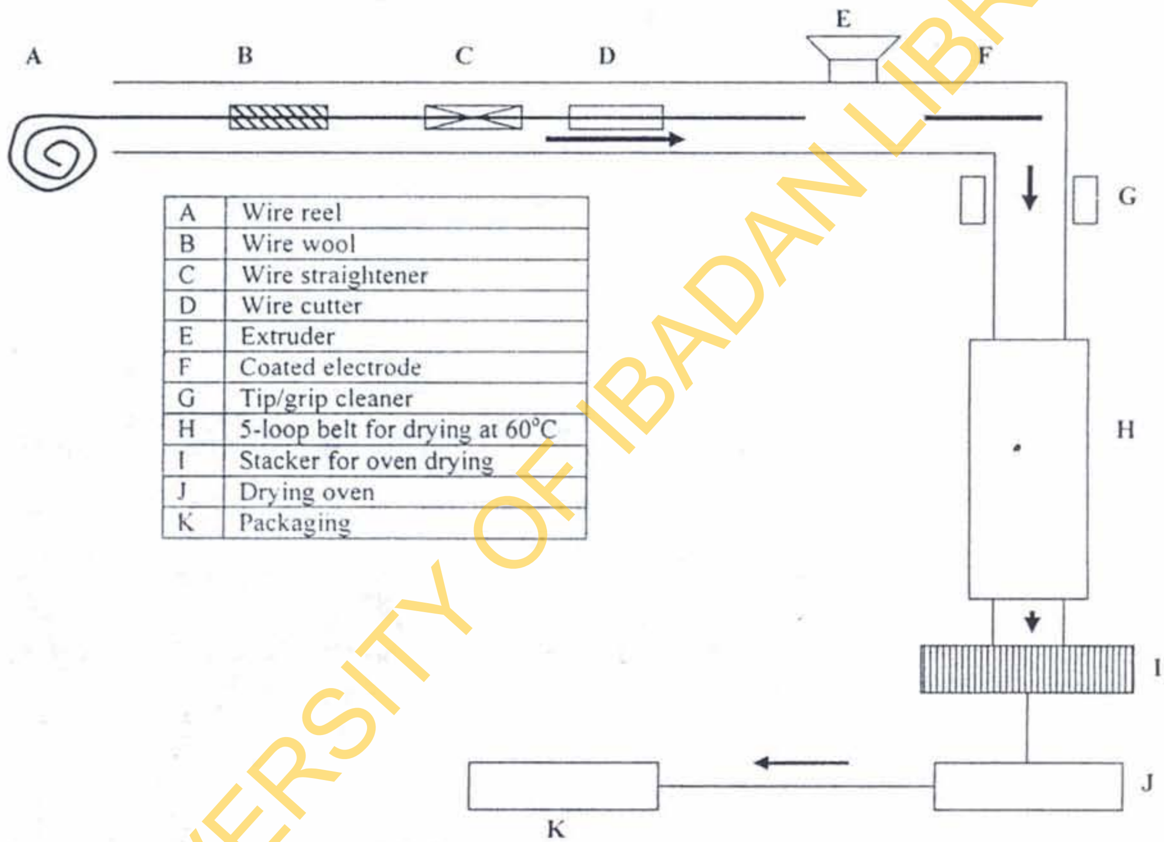

Fig. 2 Schematic representation of a typical flow line for the manufacture of coated electrodes.

(a) All-weld specimens were produced with the electrodes in v-grooves. The all weld strip was cut using cutting discs to avoid raising the temperatures excessively. These were then turned to dimension suitable for tensile tests on the Monsanto Tensometer and tensile tests were carried out.

(b) Test pieces were produced for weld analysis on the Optical Emission Spectrometer at the laboratories of the Delta Steel Company Aladja

(c) Metallographic examination and weld analysis of the test pieces were carried out.

Results

Metallographic examination of the all-weld specimen A shown in Plate 1 revealed a uniform ferrite distribution as white patches. This is essentially the same as specimen B shown in Plate 2 which is a popular commercial brand.

Plate 1: Test Electrode

Plate 2: Commercial Electrode

Results of the mechanical tests are shown in Tables 2 to 6.

Table 2 Tensile test result for Test electrode

Factor	Test sample				
	1	2	3	4	5
Original diameter	5.0	5.0	5.0	5.0	5.0
Gauge length	60.0	60.0	60.0	60.0	60.0
Final length	67.0	65.0	68.0	66.0	68.0
Maximum load (N)	10726	10945	10693	10742	10777
U. T. S. (N/mm^2)	546.27	557.42	554.59	547.09	548.87
% elongation	11.60	8.30	13.20	10.00	13.33

Table 3 Tensile test result for a leading commercial electrode

Factor	Test sample				
	1	2	3	4	5
Original diameter	5.0	5.0	5.0	5.0	5.0
Gauge length	60.0	60.0	60.0	60.0	60.0
Final length	69.0	68.0	67.0	67.0	68.0
Maximum load (N)	9327	10202	8764	9805	9087
U. T. S. (N/mm^2)	475.03	519.61	446.34	499.36	462.79
% elongation	15.00	13.33	11.67	11.67	13.38

Table 4 Impact test results

Electrode	Impact test values (in Joules)					Mean
	1	2	3	4	5	
Test electrode	65	66	65.5	65.3	65	65.38
Commercial electrode	67	69	69	69	68	68.4

Table 5 Electrode deposition efficiency test results

Specimen	Weight of steel plate	Weight of bare electrode wire	Weight of stubs and plate	Weight of deposit and stub	Electrode efficiency
Test electrode	212.60	11.21	222.62	10.62	89.64
Commercial	215.30	12.39	227.50	12.20	98.5

Table 6 Spark test for all-weld metal from "Test" and another commercial electtrode

Element	Percent present in test electrode	Percent present in commercial electrode
C	0.09	0.09
Si	0.19	0.27
Mn	0.49	0.375

P	T	T
S	0.004	0.015
Cr	T	T
Mo	T	T
Ni	T	T
Sn	T	T
Al	T	0.003
Cu	0.004	0.02
V	0.021	0.018

DISCUSSION

The weld analyses in Table 6 show that the contents were essentially the same as those from a leading commercial electrode. The spark test results show that the requirements of the electrode manufacturers has been met. Carbon and silicon which were the offending elements were at acceptable levels in the test electrode. The tensile test, impact and efficiency test results (Tables 2 – 5) were within acceptable levels.

CONCLUSION

We conclude that wire produced from Nigerian steel has been successfully used as electrode core wire with acceptable results. The ultimate tensile strength of 550.8 N/mm$_2$ and percent elongation of 11.29 are within the range for E6010 properties.

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