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Scrap Iron and Steel Recycling in Nigeria

By

Elijah I. Ohimain

Research Article

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Elijah I. Ohimain

Bioenergy and Environmental Biotechnology Research Unit, Biological Science Department, Faculty of Science, Niger Delta University, Wilberforce Island, Bayelsa State, Nigeria.

E-mail: eohimain@yahoo.com

ABSTRACT

Nigeria is blessed with abundant iron ore deposits of nearly 3 billion tonnes and other basic minerals for steel production including coal and limestone. Yet the Nigerian steel sector has collapsed principally due to shortage of raw materials particularly iron ore for the integrated steel plants and billets for the rolling mills. The privatization of the steel sector that was done in 2004-2005 was unable to revive the sector. The study found that the Nigeria steel sector is now being sustained through the recycling of scrap steel obtained mostly from municipal solid wastes. In many of the rolling mills, 100% scrap steel is recycled for the production of iron bars used for civil construction. Scrap steel recycling results in the generation of <7% and 7 – 15% slag for low and high carbon steel respectively. The paper presented the energy and environmental benefits of scrap steel recycling for the production of new products and sustenance of the Nigerian steel sector.

Keywords: Billets, furnace, iron ore, integrated mills, rolling mills, slag.

INTRODUCTION

The management of solid wastes has been a major challenge in Nigeria. Solid wastes are frequently disposed along the streets, gutters, drainage channels, rivers, abandoned plots of land etc. poor waste disposal has been linked to blockage of gutters and other drainage channels causing flood, poor aesthetics, release of foul odour and greenhouse gases, obstruction of traffic flow and pollution of surface and ground water (Abah and Ohimain, 2010; Oyoh and Evbuomwan, 2008). Scrap metals is an important components of the municipal solid wastes (MSW) in Nigeria accounting for 1.8% (Olanrewaju and Ilemobide, 2009), 10.8% (Ayotamuno and Gobo, 2004) and 3 – 20% (Nabegu, 2010) of the MSW generated in South West, South East and North Western part of the country respectively. Through the activities of scavengers useful materials are often recovered from MSW including metal scraps, wood, plastics etc (Nabegu, 2010; Adebola, 2006; Nzeadibe, 2009; Scheinberg, 2012; Manhart et al., 2011; Medina, 2010; Umaru, 2010). Scrap metals are among the most important and most priced materials in MSW. Many important metals have been recovered and recycled including iron and steel, copper, brass, aluminum (USGS, 2002; Onwughara et al., 2010; Norgate et al., 2007). Recycling of scrap metals prevent air, water and soil pollution, saves energy and raw materials and reduce greenhouse gas emissions. Recycling also conserve space in landfill sites. Energy savings during the recycling of metals are 95% for aluminum, 85% for copper, 65% for lead and 60% for zinc (USEPA, "Benefits of Recycling Scrap Metal". http://www.norstar.com.au/Recycling/Processing/Benefits.aspx. accessed 12 October 2012). Recycling contributed 76.9 metric tonnes of metal, valued at $ 14.2 billion or 58% of apparent metal supply in the US (Papp, 200I).

Iron ore is one of the most important mineral today. By weight, iron and steel accounted for 88.6% of apparent metal supply and by value, it accounted for 27.7% (Papp, 2001). Steel is produced from iron ore at high temperature usually in furnace and requiring limestone, coal and power. The process is highly energy intensive. For instance, the production of steel via blast furnace/ blast oxygen furnace (BF/ BOF) has an energy demand of 23 MJ/kg and global warming potential of 2.3 kg CO_2e /kg (Norgate et al., 2007). Recycling of steel therefore saves energy, material and reduces greenhouse gas emissions. Fenton (2002) reported that recovery of 1 metric tonne of steel from scraps conserves an estimated 1,030 kg of iron ore, 580 of coal and 50 kg of limestone. US EPA reported that for every tonne of steel produced from scrap steel saves 1.115 kg of iron ore, 625 kg of coal and 53 kg of limestone, using recycled steel saves 75% of energy, 90% raw materials, reduces air pollution by 86%, water use by 40%, water pollution by 76% and mining wastes by 97%.

The estimated annual per capita consumption of steel in Nigeria is increasing, astronomically ranging from 5 kg in 1968 (Adedeji and Sale, 1984) to 130 kg in 2012 (Uzondu, 2012). Unfortunately, this increase in the demand of steel products has not been met by domestic production, despite the abundant iron ore, coal and limestone reserves in the country. The Nigerian iron and steel sector have reached a stage of near collapse. The only iron ore beneficiation plant located at Itakpe is down and unable to supply iron ore to the two integrated steel plants, Ajaokuta Steel Company (ASC) and Delta Steel Company (DSC). The DSC, which depends on imported iron ore from Brazil and Liberia is epileptic and unable to supply billets to the three government owned inland rolling mills (Oshogbo, Kastina and Jos), which are also down (Mohammed, 2002). The country is losing a lot of foreign exchange on the importation iron ore and billets, and many companies are unable to cope with the rising cost. Besides, Nigeria has 13 rolling mills and 7 mini that depends on billets. These companies are threatened by the shortage of raw materials (billets) from DSC. The total national long products rolling capacity is 3.18 million tonnes annually, unfortunately, there are not enough billet to satisfy this capacity. Hence, attention has now been focused on the use of steel scrap for the production of reinforced bars by the 20 rolling and mini steel mills. A recent study revealed that 83 – 86% of scrap metals recovered from MSW in Bayelsa state, Nigeria consists of iron and steel (Ohimain and Jenakumo, unpublished data). Recent reports have also shown that scrap steel are sold to rolling mills in Warri, Lagos, Onitsha, Kano, Ibadan etc (Uzondu, 2012; Manhart et al., 2011; Nzeadibe, 2009). Most mills are now resulting to the use of scrap steel as raw material due to the shortage of billets in the country. Hence, this study is focused on scrap iron and steel recycling in Nigeria using DSC as a case study.

Overview of iron and steel sector in Nigeria

Iron and steel is pivotal to the industrialization and development of any country. Iron and steel are required in construction works including bridges, buildings, household appliances, processing/manufacturing plants, equipment, vehicles, oil and gas infrastructure etc. Nigeria has nearly 3 billion tonnes of iron deposits found in Kogi, Enugu and Niger states (Embassy of Nigeria in Hungary, 2012). Alafara et al. (2005) reported that Nigeria has workable iron ore deposits in excess of 2.5 billion tonnes most of which belong to hematite, hematite-magnetite, hematite-geothite and siderite-geothite grades. The country also has other raw materials in addition to iron ore for the production of steel particularly coal and limestone. Nigeria has nearly 3 billion tonnes of indicated coal reserves in 17 coal fields, with over 600 million tonnes of proven reserves. Though, the RMRDC (2009) reported a more conservative estimate of Nigerian coal to be 1.2 billion tonnes of proven, indicated and inferred deposits. Limestone deposits in Nigeria are in excess of 700 million tonnes (RMRDC, 2001). Nigeria therefore has all the raw materials for the production of iron and steel from primary raw materials (solid minerals), but unfortunately, the country has not been able to establish a stable iron and steel sector.

Organized mining in Nigeria began in 1903 and by 1940s; Nigeria was a major producer of important minerals including tin, columbite and coal (Mallo, 2012). Planning for the Nigerian steel industry started in 1958. Exploration work on the Itakpe iron ore deposits began in 1963 (Akinrinsola and Adekeye, 1993). On April 4th 1971, the Nigerian Steel Development Agency (NSDA) was established by Decree No 9, which was the body charged to oversee steel development in Nigeria. In 1972, commercial quantity of iron ore was discovered in Itakpe, Kogi state, which led to the signing of a contract in 1975 with a Soviet Company to construct an integrated iron and steel plant in Ajaokuta based on the traditional Blast Furnace/Basic Oxygen Furnace (BF/BOF) technology. The first phase of the project, which is to be completed in 1981 will have a capacity of 1.3 million tonnes of long products, which will be expanded to 2.6 million tonnes in flat products during the second phase of the project, while the third phase involve doubling the capacity to 5.2 million tonnes (Mohammed, 2002). After 37 years of intermitted construction work for the installation of production facilities and infrastructure at Ajaokuta, which had gulped about $ 4.5 billion without producing any crude steel from iron ore (Mobbs, 2002). Additional funding for the completion of the mill could not be secured from the World Bank, because the bank considered the 25 years Soviet BF technology to be obsolete. Moreover, the privatization that was done to Reactivate ASC and other steel mills in Nigeria was not transparent; it merely transformed the companies from public to private monopolies without developing steel in the country (Mohammed, 2008).

The Delta Steel Company fared slightly differently. The plant was one of the main projects of the third National development plan (1975-1980) and was conceptualized to satisfy the increasing demands for steel products and the realization of the National aspiration for self sustenance of domestic demands, rapid industrial growth and technological development. The contract for the construction of the plant was awarded in 1975 to a German-Austrian consortium to build a turn-key electric arc furnace with Direct Reduced Iron (DRI) technology in Aladja, Delta state. The project was completed on schedule in 1981 and became operational in January 1982. It has an installed capacity of 1 million tonnes of liquid steel, 960,000 metric tonnes of billets and 320,000 tonnes of rolled products annually, while 210,000 tonnes are to be supplied to three inland rolling mills located in Kastina, Oshogbo and Jos for the production of long products, basically wire and reinforcing bars. Delta Steel Company operates the first integrated

Steel Plant in Nigeria, producing steel from basic raw materials. However, due to the combined factor of poor funding, and government interference, DSC has operated at very low capacities (Mohammed, 2002). However, following the privatization of many governments owned steel plants in 2004; DSC has become operational while ASC is still moribund. With the epileptic operations of the DSC, it was unable to effectively supply billets to the inland rolling mills.

Iron ore discoveries at Itakpe reached 200 million tonnes in 1977 (Ola et al., 2009). Out of the nearly 3 billion iron ore reserve in Nigeria (Table 1) (Adebimpe and Akande, 2011; Bamalli et al., 2011), only the Itakpe iron ore mine have been developed, which started production in 1979.

Table 1: Iron Ore Proven Reserves in Nigeria

Location	% iron content	Reserves (million tonnes)
Agbaja	45-54	2000
Itakpe	36	200
Ajabanoko	35.61	62.5
Chokochoko	37.43	70
Agbade-Okudu	37.43	70
Nsude Hills	37.43	60
TOTAL		2462.5

Source: Adebimpe and Akande (2011)

The Itakpe iron ore has an iron content of 36%. Hence, the Nigeria National Iron Mining Company Ltd (NIOMCO), Itakpe was established to upgrade the ore to 63 – 64% Fe content suitable for blast furnace at ASC and 66 – 68% Fe suitable for DRI at DSC (Ola et al., 2009). NIOMCO was designed to produce and supply 100% of the iron requirement of ASC amounting to 2.15 million tonnes/year and 40% of the iron requirements of DSC amounting to 0.5 million tonnes/year. Though, privatized, the NIOMCO, Oshogbo rolling mills, Jos rolling mills and Katsina rolling mills are also moribund. The entire iron and steel industry in Nigeria (Table 2) is at the brick of collapse due to the failures NIOMCO, ASC and the poor performance of DSC. Many of these steel companies now operate their plants mostly using scrap iron.

Table 2: Steel companies in Nigeria

Types of mills	Plant location	Rolling capacity (tons per year)	Products
Integrated mills (2)	Ajaokuta Steel Co. Ltd. Ajaokuta	540,000	Bars, rods, light sections
	Delta Steel Co., Ovwian/Aladja	320,000	Bars; rods; sections
Rolling mills (13)	Alliance Steel Co., Ibadan	20,000	Bars
	Alliance Steel Co., Onitsha	20,000	Bars
	Asiastic Manarin Ind., Ikeja	60,000	Bars, sections
	Jos Steel Rolling Company, Jos	210,000	Bars, rods
	Kastina Steel Rolling Co. Kastina	210,000	Bars, rods
	Kwara Commercial, Metal and Chemical Industries, Ilorin	40,000	Bars
	Mayor Eng. Co., Ikorodu	220,000	Bars, sections
	Metcombe Steel Co., Owerri	10,000	Bars, sections
	Oshogbo Steel Co., Oshogbo	210,000	Bars; rods
	Qua Steel Products, Eket	600,000	Bars, sections
	Selsametal, Otta	100,000	Bars
	Union Steel Co., Ilorin	20,000	Bars
	Baoyao futurelex, Abuja	20,000	Bars
Mini mills (7)	Federated Steel Industry, Otta	140,000	Bars, sections
	General Steel mill, Asaba	50,000	Bars
	Universal Steel Co., Ikeja	80,000	Bars, sections
	Nigerian Spanish Eng. Co., Kano	100,000	Bars
	Nigersteel Co., Enugu	40,000	Bars, sections

Table 2 Continues

	Continental Iron and Steel Co., Ikeja	150,000	Bars, sections
	Kew Metal Industries, Ikorodu	20,000	Bars, sections
TOTAL		3,180,000	

Source: Modified from Mohammed (2002)

Scrap iron recycling in DSC

DSC is pivotal to the actualization of iron and steel objectives in Nigeria. The mill was built at Aladja with navigable access to Warri port for importation and exportation of iron ore, billets and steel products. The mill is equipped with electric arc furnace supplied with National gas from nearby oil fields for direct reduced iron processes. The company is linked with the NIOMCO via a rail track. The location of the company at Aladja is well serviced by several link roads including the East-West Road, DSC-Enerhen Road and DSC-Effurun Express Road. The company is close to the Osubi Airport.

Typically, scrap ferrous metal are generated at household, auto-mechanic workshops and other commercial ventures (Fig. 1).

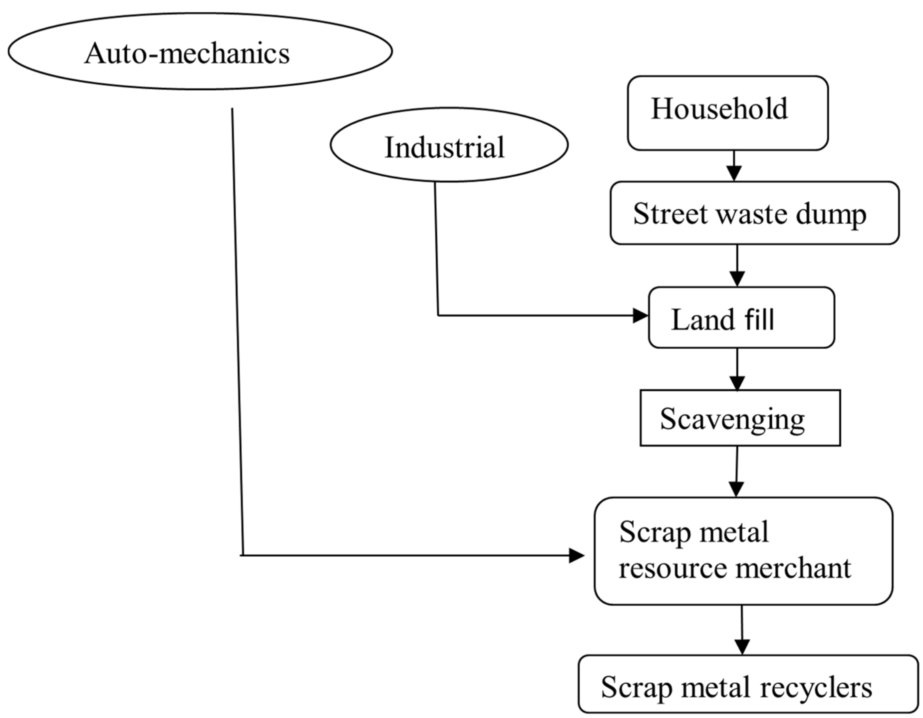

Fig 1: scrap iron generation in Nigeria

Scavengers i.e. waste pickers recover scrap iron from waste dumps and sell them to scrap dealers, who in turn supply the scrap to steel mills using 30 tonne truck (Fig. 2).

Fig. 2: Scrap iron transportation

The process of iron making in DSC is summarized in Table 3.

Table 3: Iron making process in Delta Steel Company

Plant	Process	Product
Pellet Plant	The Pellet Plant constitutes the first stage in the iron making process. The pellet plant is designed to produce 1.5 million tonnes of oxide pellets per annum. Iron ore is dried to a maximum moisture content of 1% and then ground in a ball mill to 0.045mm. The fine ore is then mixed with hydrated lime and water, thereby forming slurry which is agglomerated in pelletizing discs into green pellets. At the indurating machine, the green pellets are fired and hardened at a temperature range of 850℃ - 1,300℃. The pellets are screened to the required size range of 5 - 25mm.	Iron oxide pellets
Direct Reduction Plant	The process utilizes reformed National gas which is fed from the bottom of the shaft furnace, counter current to the flow of oxide pellets from the top. The two 'Midrex' modules in DSC each module is designed to produce 510,000 tonnes of per annum of DRI (pure iron). The degree of metallization attained is 93%, and the size range is 10 to 15 mm in diameter. To prevent re-oxidation, the DRI is stored in four large storage bins and protected permanently with an inert atmosphere of nitrogen or seal gas.	Direct reduced iron

Table 3 Continues

Steel Melting Shop	Steel production in delta Steel utilizes the Electric Arc furnace and Continuous Casting processes.	
Electric Arc Furnace & casting plant	The electric arc Furnace Shop consists of three, 110t capacity furnaces and one ladle furnace each connected to a 60 MVA transformer. The melt charge is an average of 80% DRI and 20% scrap. Normally, the scrap is melted first followed by the introduction of DRI from the furnace roof through a vibro feeder. Impurities in the resultant liquid metal are removed as slag with the aid of burnt lime and oxygen. The steel is tapped into preheated ladles and transferred to the continuous casting shop after purging and addition of ferro alloys. The continuous casting plant consists of three, 6 strand continuous casting machines. Molten steel supplied to the continuous casting shop is held in a ladle turret and thereafter teemed into pre-heated tun dishes which distribute the liquid steel into six moulds. The billet cast has 0.12 x 0.12 x 12 m^3.	Billets
Rolling Mill	The Rolling Mill is an 18-stand mill capable of producing 320,000 tonnes per annum of light sections. Typically, the rolling of billets passes through the following basic process:- • Reheating: The billets are reheated to a temperature of 1200℃ in a pusher type furnace. • Roughing: The hot billets are passed through the roughing stand for the removal of scales and initial deformation • Intermediate Rolling: The Billet size is reduced by approximately 50% and deformed progressively into the appropriate shape for finishing operations. • Roughing: The final rolling operations take place here at the finishing stands. • Additional processes involve the cooling of the products to ambient temperature, cutting to market lengths, straightening if necessary, stacking and bundling.	Light sections (flats, channels, angles, I-beams and bars)

Compiled from DSC website, http://www.deltasteelcompany.com/aboutus.html accessed 29 October 2012

The iron making process consists of 2 Midrex 600 series Direct Reduction Furnace and 3 number 6 strand casting process for billets. The paramount advantage of utilizing the Midrex Direct Reduction process at DSC is the abundant availability of the otherwise flared National gas. About 40 % of the iron ore used in DSC is obtained from NIOMCO (when functional) and 60% imported. Steel production in DSC utilizes the Electric Arc furnace and Continuous Casting processes. The utilization of electric arc furnaces is inevitable in view of the use of solid direct reduced iron while, on the other hand, the continuous casting of steel has become widely acceptable in view of its higher yield compared to conventional ingot casting.

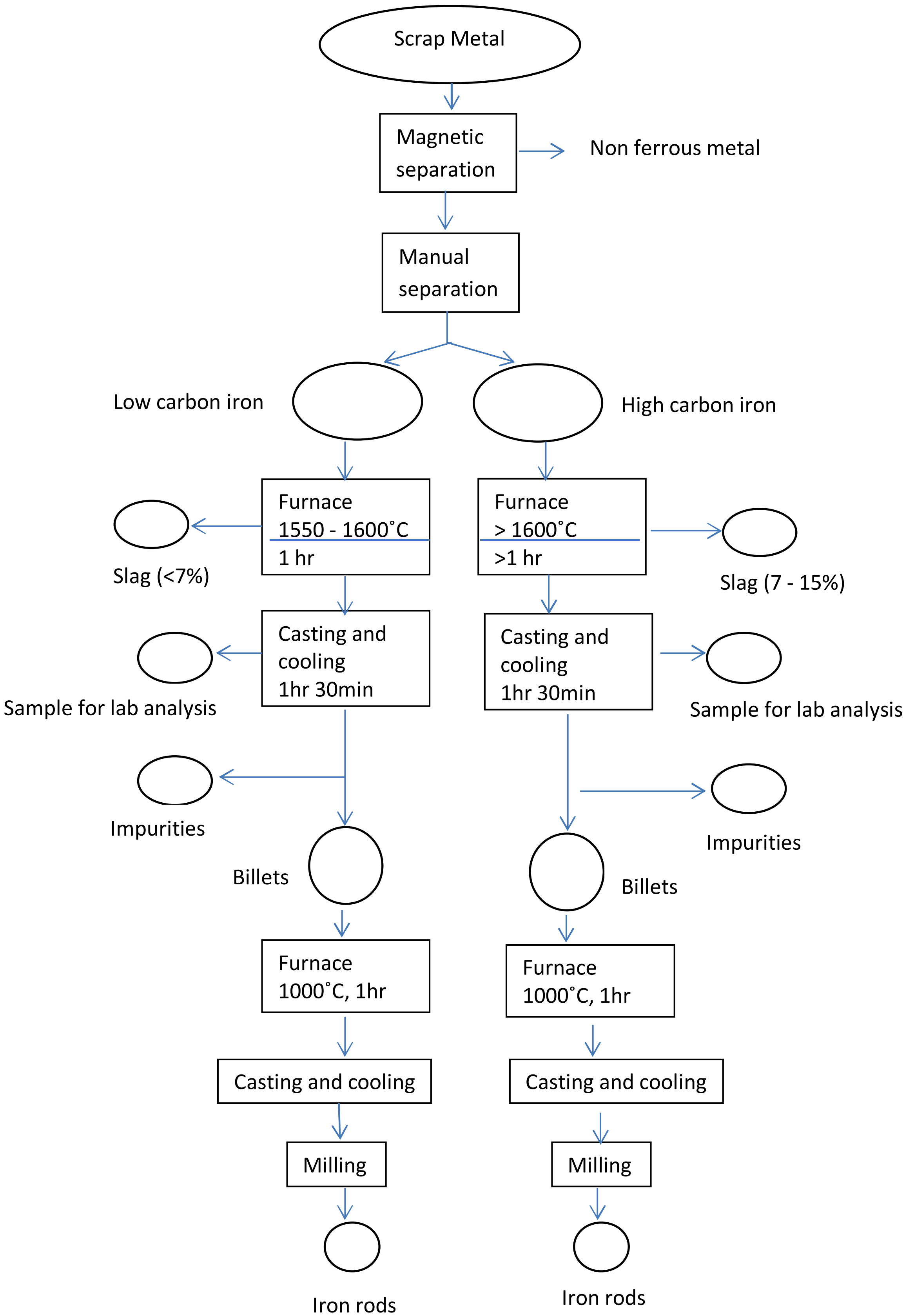

Fig. 3: Scrap iron recycling process

As part of the study, a field visit was undertaken to Delta Steel Company, to find out how the scrap metal is recycled. DSC produces iron from basic raw materials and recycles scrap iron to new products for reuse. Scraps are typically brought to the point of reception by the heavy- duty trucks. The scraps are sorted in 2 ways, namely, magnetic and manual separation. Non-ferrous metal is separated from the ferrous metal using magnetic separation devices. Manual separation is used to separate the ferrous metals into two phases, the low carbon iron and the high carbon iron. The high carbon metal takes longer time to melt and produces more wastes (slag), while the low carbon iron produce fewer slag and melt faster. Figure 3 presents the flow chart for the production of iron bars using 100% scrap metals. Less than 7% slag is produced in high quality scrap metal, while 7 – 15% is produced in low quality metal. This value reported in this study is comparable to the 10 – 15% slag that is typically formed during the processing of 60 – 65% Fe content iron ore with BOF (Kalyoncu, 2001). Like in other countries, the slag produced in DSC is used as aggregates for road construction (Kalyoncu, 2001). The DSC steel plant was designed to run on 80% DRI and 20% scrap. BOF like that of ASC can use between 25 and 36% recycled steel to make new steel, while electric arc furnace like that of DSC can utilize almost 100% recycled steel. Due to the shortage of iron ore, DSC and most of the other rolling mills now operate on 100% scrap iron for the production of new products.

CONCLUSION

Nigeria is blessed with abundant iron reserves. The country has nearly 3 billion tonnes of iron ores located in six fields; Agbaja, Itakpe, Ajabanoko, Chokochoko, Agbade-Okudu and Nsude Hills. There are other deposits that are currently under investigation. The iron content of the proven ore reserves is in the range of 36 – 54%. Out of the six Nigerian iron ore field, only Itakpe, with an iron content of 36% has thus far been developed. The NIOMCO at Itakpe was designed to supply iron ore to both ASC and DSC, which in turn ought to supply billets to rolling mills in the country. Nigeria has installed steel rolling capacity of 3.18 million tonnes per annum. Nigeria has 2 integrated steel plants, 13 rolling plants and 7 mini plants. Due to poor contracting strategy, ASC was never completed after 37 years of intermittent construction. NIOMCO and DSC folded up, which led to the collapse of the rolling mills due to shortage of iron ore and billets. The government embarked on privatization in 2004-2005 in order to revive the moribund steel sector. Unfortunately, the privatization process was not transparent. Only the DSC has thus far returned to production, though at low capacity. The shortage of iron ore is mostly responsible for the collapse of the iron and steel sector in Nigeria. However, many of the rolling mills including the DSC have resorted to the use of 100% scrap steel recovered from municipal solid wastes for the running of their mills. Scrap iron and steel recycling has virtually sustained the Nigerian steel sector, creating employment and wealth, conserving landfill space, reduction in material and energy use and environmental protection.

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