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Production of Ductile Iron Using Indigenously Manufactured Rotary Furnace

O.A. Adeyemi[1], I.M. Momoh[2], S.O.O. Olusunle[1] and S.B. Adejuyigbe[3]
[1]*Engineering Materials Development Institute, Akure, Nigeria.*
[2]*Depertment of Metallurgy, Kogi State Polytechnic, Lokoja, Nigeria.*
[3]*Federal University of Agriculture, Abeokuta, Nigeria.*

Abstract: *Production of ductile iron using an indigenous 100kg rotary furnace was achieved using the ladle treatment/sandwich cover ladle method. Powdered Ferrosilicon magnesium of 400g was used as a nodularizer together with powdered Ferrosilicon of 20g was used as innoculant. The nodularizer was put in a cylindrical pocket at the base of the ladle with a circular fitting steel plate cover welded to a handle which was removed immediately after tapping the molten metal from the rotary furnace. The resulting melt was subsequently poured into the mould after the violent reaction between the molten metal and the nodularizer. Samples of the as-cast were subjected to metallographic process and characterized using a Nikon Eclipse metallurgical microscope and a Hilger Analytica atomic mass absorption spectrometer for percentage elemental analysis. The average percentage element weight of the samples and microstructures of 200X and 400X compared favourably with the ductile iron produced from standard procedure.*
Keywords: *ductile iron, rotary furnace, nodularizer, microstructures.*

I. Introduction

Ductile iron, also called ductile cast iron, spheroidal graphite iron, or nodular cast iron, is a type of cast iron invented in 1943 by Keith Millis. While most varieties of cast iron are brittle, ductile iron is much more flexible and elastic, due to its nodular graphite inclusions. The graphite enhances the desirable properties of cast iron like improved casting & machining properties and better thermal conductivity. In ductile iron, the graphite is in the form of spherical nodules- rather than flakes which is found in typical cast iron- which inhibit the creation of cracks and providing the enhanced ductility that gives the alloy its name. The formation of nodules is achieved by addition of nodularizers (for example, magnesium or cerium) into the melt. Ductile iron has enormous advantages over its steel counterpart; it has better mechanical properties with wide range of applications in the automotive industry [1], defence [2], agriculture [3,4], construction and mining components [5] e.t.c.

Rotary furnace is a typical example of a fuel-fired furnace which is known for its ease in operation, low cost of operation, fuel economy, low cost of manufacture, high thermal efficiency and low maintenance. The rotary furnace consists of a cylindrical, refractory lined steel drum supported by a structural steel frame, in-between two conical frustums. The conical frustums are of two different diameters. The primary heat source of the furnace could either be a natural gas burner or a liquid fuel burner [6,7].

To this end, this work intends to show that ductile iron production can be achieved using an indigenously manufactured rotary furnace.

II. Experimental Work

2.1 Charge Material for Ductile Iron

Cast iron scrap (engine sleeve Carbon 2.8-3.3; Silicon 1.8-2.5; Manganese 0.5-0.8; Phosphorus 0.3 max and Sulphur 0.12max ASTM E-535) of about 40kg was used. The nodularizer, powdered Ferrosilicon Magnesium of about 400g was used; Ferrosilicon of about 20g was used as the inoculant. The ladle treatment/sandwich method developed by Skjegestad and Skaland was adopted for the ladle design. The ladle was prepared having a pocket at the base of the ladle with ferrosilicon magnesium deposited and covered with tiny mild steel plates and a Y-block patterned mould was prepared, using green sand.

2.2 Production Process of Ductile Iron Production

The first stage was to preheat the rotary furnace for about seventy minutes before charging the 40kg scrap. The inoculant was subsequently added thereafter to the melt in the furnace according to Olusunle procedure [8]. The melt was subsequently tapped into the ladle where a violent reaction between the melt and the nodularizer was observed for about 10 seconds before being poured into the mould. Two different melting operations were carried out and the melts were tapped at temperature 1480°C and 1500°C respectively.

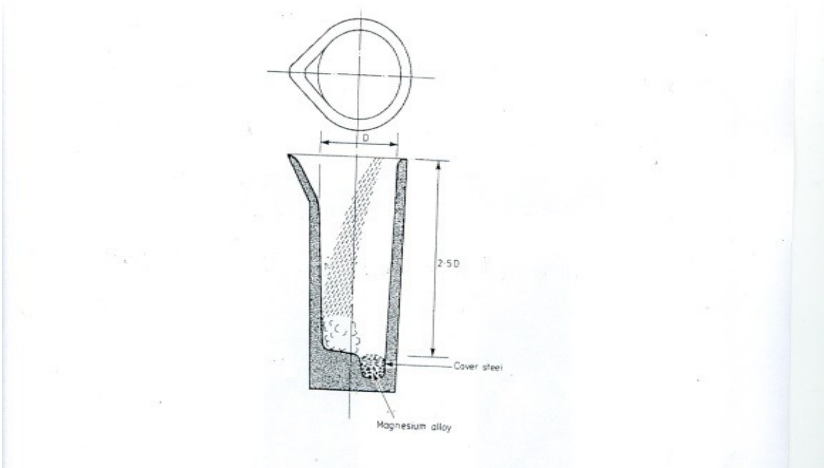


FIGURE 2: Sandwich Cover Ladle Design [9].

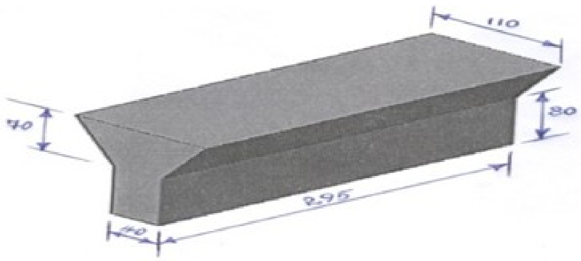


FIGURE 3: Y- Block Pattern used for Ductile Iron Production [2]

III. Results And Discussions

3.1 Chemical Composition of Ductile Iron

The as cast samples were subjected to the Hilger Analytica atomic mass absorption spectrometer for chemical composition analysis. The table below shows the weight percent of the elements in the 10 samples.

TABLE 3.0: Elemental Chemical Composition of Ductile Iron Samples

ELEMENT (Wt%)	**C**	**Si**	**Mn**	**Mg**	**S**	**P**
SAMPLE 1	3.60	2.10	0.30	0.05	0.009	0.04
SAMPLE 2	3.60	2.00	0.25	0.04	0.009	0.035
SAMPLE 3	3.40	2.10	0.30	0.04	0.010	0.035
SAMPLE 4	3.50	2.00	0.30	0.05	0.009	0.035
SAMPLE 5	3.50	2.00	0.20	0.05	0.009	0.035
SAMPLE 6	3.60	2.00	0.20	0.05	0.01	0.04
SAMPLE 7	3.60	2.00	0.25	0.05	0.01	0.04
SAMPLE 8	3.60	2.10	0.30	0.04	0.01	0.04
SAMPLE 9	3.50	2.00	0.25	0.05	0.01	0.04
SAMPLE 10	3.60	2.00	0.30	0.04	0.01	0.03
TOTAL	35.50	20.30	2.65	0.46	0.096	0.37
AVERAGE	**3.60**	**2.00**	**0.30**	**0.05**	**0.01**	**0.04**

SOURCE: Adeyemi (2007)

The percentage carbon value was more than the value range of the engine sleeve scrap used. The Silicon and Manganese values of cast produced using the rotary furnace was within the range of values of the engine sleeve scrap. The Phosphorus and Sulphur values were well below the maximum values of the sleeve scrap used.

3.2 Micrographs of Ductile Iron

The samples were also subjected to metallographic process and characterized using the Nikon Eclipse metallurgical microscope. The microstructures below reveals its morphology.

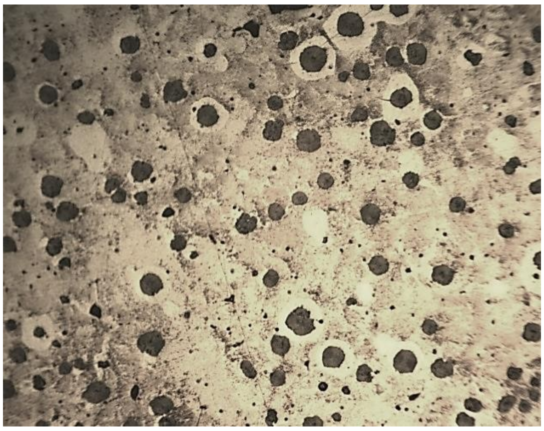


Figure 3(a): Microstructure of ductile iron produced from indigenously manufactured rotary furnace (200X).

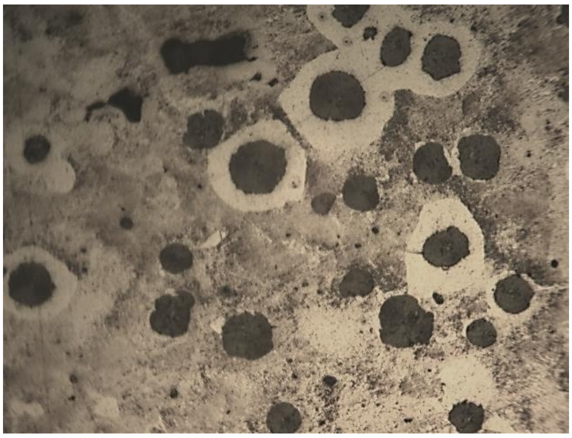


Figure 3(b): Microstructure of ductile iron produced from indigenously manufactured rotary furnace (400X).

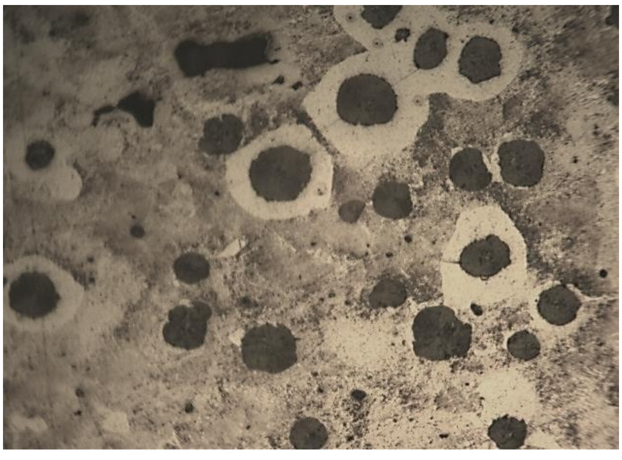
The microstructure shows graphite globules dispersed all over the pearlite ferrite matrix. Some globules are seen surrounded by ferrite matrix, this is the characteristic bullseye structure peculiar to ductile iron.

IV. Conclusion

The values of the chemical composition of the cast was found to be similar to that of the 500-7 SG Iron grade. Its values are:

Carbon	3.40-3.85%	Phosphorous	0.10% max
Manganese	0.10-0.30%	Sulphur	0.02% max
Silicon	2.30-3.10%	Magnesium	0.07% max
		Iron	balance

Also, the microstructure of the samples compared favourably with the standard micro structure of ductile iron, showing the characteristic 'bulleye' feature.



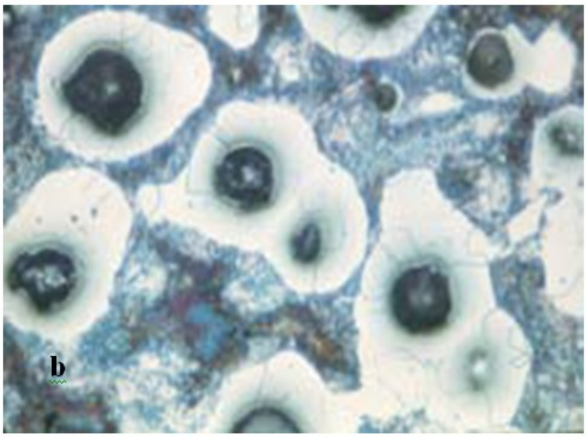


Figure 4: Showing the microstructure of ductile iron produced from [400X] (a) EMR100 rotary furnace and (b) ductile iron produced from induction furnace. Source: (a) Adeyemi (2007); (b) ASM Handbook (2004)

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