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Influence of Periwinkle Shell addition on Mechanical Properties of Gray Cast Iron

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Abstract

Gray iron is one of the oldest cast ferrous products and it is still used for those applications where its properties have proved to be the most suitable material available. The presence of high phosphorus contents should be avoided since Fe_3P is brittle and lowers strength considerably. Its presence tends to promote increased shrinkage. In search of the ways to improve the mechanical properties, this research work tends to study the influence of periwinkle shell particulate on the mechanical properties of grey cast iron. Over the years, large quantities of periwinkle shells have been accumulated in many parts of the country (Nigeria). The shells have become a serious source of land pollution in areas where they are found. In an attempt to carry out the study, the periwinkle shell was crushed to fine particles and added to gray cast iron. The mass of powdered periwinkle shell was varied from 100 to 500 g while the mass of gray cast iron was constant. The results obtained showed that the Carbon, Silicon, Manganese, Phosphorus, Sulphur, Chromium and Nickel contents decrease with increasing amount of the periwinkle shell, while Molybdenum increases. The hardness was found to be decreasing while the tensile strength increases.

Keywords: *Gray Cast Iron, Hardness, Periwinkle Shell, Tensile Strength and Flakes*

1. Introduction

MacKenzie (1944) referred to cast iron as "steel plus graphite." Although this simple definition still applies, the properties of gray iron are affected by the amount of graphite present as well as the shape, size, and distribution of the graphite flakes.

The widespread use of cast iron results from its low cost and versatility. Its versatility arises from the wide range of physical properties which are possible due to the addition of alloying elements and various heat treatment procedures (Seidu, 2014).

Plate 1 Periwinkle shell

The common periwinkle or winkle, scientific name *Littorinalittorea*, is a species of small edible sea snail, a marine gastropod mollusk which has gills and an operculum, and is classified within the family *Littorinidae*, the periwinkles. The shell as shown in plate 1 is broadly ovate, thick, sharply pointed except when eroded. The shell contains 6 to 7 whorls with some fine threads and winkles. The colour is varied from grayish to gray-brown, often with dark spiral bands. In this study, the shell is used as an additive to improve the mechanical property of gray cast iron.

Gray iron is one of the most easily cast of all metals in the foundry. It has the lowest pouring temperature of the ferrous metals, which is reflected in its high fluidity and its ability to be cast into intricate shapes. As a result of this peculiarity during final stages of solidification, it has very low and, in some cases, no liquid to solid shrinkage so that sound castings are readily obtainable (Rehder, 1965). For the majority of applications, gray iron is used in its as-cast condition, thus simplifying production. Gray iron has excellent machining qualities producing easily disposed of chips and yielding a surface with excellent wear characteristics. The resistance of gray iron to scoring and galling with proper matrix and graphite structure is universally recognized.

Gray iron castings can be produced by virtually any well-known foundry process. Surprisingly enough, in spite

Table1: Spectrometer analysis

P / GCI	0g	100g	200g	300g	400g	500g
%C	3.440	3.294	3.115	2.99	2.72	2.650
%Si	1.930	1.783	1.628	1.51	1.32	1.180
%P	1.110	0.906	0.693	0.470	0.313	0.116
%S	0.138	0.132	0.126	0.119	0.113	0.110
%Mn	0.460	0.427	0.394	0.272	0.381	0.375
%Cr	0.071	0.067	0.063	0.062	0.055	0.047
%Ni	0.084	0.081	0.079	0.078	0.070	0.046
%Mo	0.009	0.011	0.012	0.0137	0.015	0.262

of gray iron being an old material and widely used in engineering construction. The mechanical properties of gray iron are not only determined by composition but also greatly influenced by foundry practice, particularly cooling rate in the casting. All the carbon in gray iron, other than that combined with iron to form pearlite in the matrix, is present as graphite in the form of flakes of varying size and shape. It is the presence of these flakes formed on solidification which characterise gray iron. The presence of these flakes also imparts most of the desirable properties to gray iron (Umezurike and Onche, 2010).

The grey iron microstructure is normally determined by the base iron composition, the solidification cooling rate and the inoculation process. Grey cast iron has flat flakes as shown in figure 1, which exerts a dominant influence on its mechanical properties. The graphite flakes act as stress raisers which may prematurely cause localised plastic flow at low stresses, and initiate fracture in the matrix at higher stresses and fracture takes place along the flakes. As a result, it forms serious fragmentation and exhibits no elastic behavior (Basdogan, 1982).

Plate 2 Graphite Flakes in Gray Cast iron

2. Materials and Methods

2.1 Materials Collection

Scraps of gray cast iron were bought from local market in Lagos, Nigeria and it was sparked to know its chemical composition. Periwinkle shell was collected from waste bin in the market.

2.2 Materials Preparation

The periwinkle shell was washed and sun dried to remove the moisture content, it was crushed and ground into powder.

2.3 Moulding and pattern design

Sand moulds were made in which square and cylindrical patterns of dimension (80×60×10 mm) and diameter 15 mm respectively were placed

2.4 Furnace and casting

Pit furnace was used for the melting which operated at a temperature of 1400^{0}C, and the pouring temperature of 1370^{0}C. The furnace uses diesel and a blower as a source of energy. 5 kg of gray cast iron was placed in the crucible pot and allowed to melt, and then 100 g, 200 g, 300 g, 400 g, and 500 g of powdered periwinkle shell was weighed and poured into it separately to obtain different samples. The powdered periwinkle shell was allowed to dissolve in the melt and it was rigorously stirred to obtain a uniform solution. The melt was then poured into the moulds to get the cast of different composition. When the cast on each mould was cooled and solidify, each was removed from the mould and various tests were conducted.

No machining was done on the cylindrical samples to be used for the tensile test. They were only sand papered to remove the casting sands and subjected to tensile test. The samples for the hardness test were machined to (15 mm × 20 mm × 5 mm) which was ground and polished using the grinding machine.

Also, samples were cut using the hack saw to carry out the spectrometer analysis.

3. Result and Discussion

The results of the spectrometric analysis as shown in Table 1 and Figures 1 and 2 Show that as the mass of periwinkle shell additive is increasing, the percentage of carbon, silicon, phosphorous, sulphur, manganese, chromium and nickel increase while molybdenum increases. This implies decrease in hardness and increase in ductility.

The result in Table 2 shows that as the percentage of periwinkle shell is increasing, the hardness value is decreasing this imply increase in ductility. At 400g of periwinkle shell, there is an increase in hardness followed by decrease at 500g. This indicates that the quantity of periwinkle shell to maintain a balance between hardness and ductility is 300g added to 5kg of gray cast iron.

Table 2: Hardness test

Mass of powered periwinkle shell (g)	Force (KN)	Diameter of indentation (mm)	Brinell Hardness Number
0g	20	2.8	324.47
100g	20	2.85	312.95
200g	20	3.0	281.78
300g	20	3.1	263.46
400g	20	2.9	302.02
500g	20	3.3	231.68

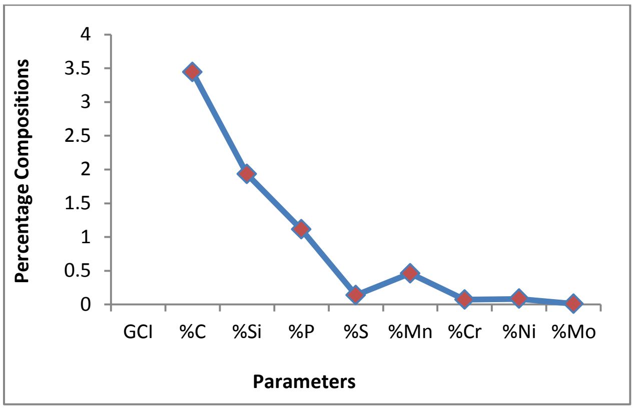

Figure 1 Chemical composition of gray cast iron before additive

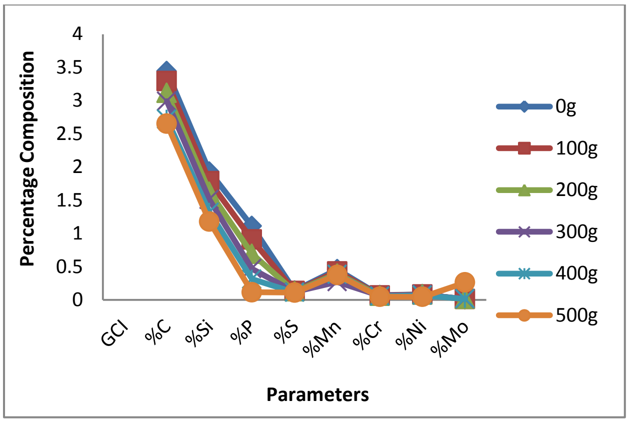

Figure 2 Chemical composition of gray cast iron after additive

$BHN = 2 F / (\pi D (D - (D^2 - d^2)^{1/2}))$ (1)

where
D = Diameter of Steel ball = 10mm
d= Diameter of indentation

Conclusion

The powdered periwinkle shell has been able to improve the mechanical properties of gray cast iron. The ductility has been increased, hardness is been reduced and the damping capacity is increased as the phosphorus content is reduced with increasing amount of periwinkle shell. Gray cast iron has nearly all the properties that are desired for brake rotor applications. This combined with the very low costs of materials and processing makes gray cast iron a potentially unbeatable material in brake rotor applications.

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