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Particle size distribution analysis of carburized HT250 gray cast iron using ImageJ

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Abstract

The study focused on the particle size analyses of a carburized HT250 gray cast iron using ImageJ software to understand the pattern of carbon diffusion after the carburization process. Pulverized pal kernel shell was deployed in the carburization of several samples of the grey cast iron after which the samples were characterized using scanning electron microscope (SEM) to study the microstructure of each sample. More so, ImageJ was equally deployed in the analyses of the SEM

microstructures to understand the diffusion patterns of the carbon from the pulverized palm kernel shell so as to predict their structural behavior when deployed in fabrication process. Some of the important features from the ImageJ include Surface Plot, Interactive 3D surface plot and Intensity thresholding. The result showed the various diffusion patterns of carbon into the parent material. Thus, this result will help in the field of material science on the best method of material processing for adequate mechanical and structural properties.

Introduction

Cast Iron is used to describe a collection of alloys with iron in them, which are ferrous and contain 2% carbon and between 1% and 3% silicon. The level of alloying with concurrent regulation of the tempering procedure produces a very broad range of properties hence provide several grades of cast iron. Cast iron is largely preferred as a material for various reasons, including its great ability to be made into casts, ease of procurement, and high compression strength compared to steel [1]. The resistance of grey cast iron to corrosion seems, by all accounts, to vary. This variation, however, is most likely dependent on its production method [2]. However, according to [3], cast iron’s ability to withstand impact and ductility are usually limited, which reduces its application. Cast iron has and continues to have a variety of applications in various industries ranging from the production of machines, automobile parts, pipes, kitchen equipment, amongst other things. As cast irons are very fluidic in its molten state, it has high castability, hence its name[1]. The hardness properties and machinability of these different types of cast iron vary considerably [4]. Gray cast ion has wide application in the industry especially automobile industry applications including casting of the engine block of internal combustion engine [5]. According to [6], it is also often applied when making compression-ignition engines: gears, guide rails, camshafts, and engine liners. The structure of grey cast iron is determined by the chemical composition prior to casting, inoculants, and cooling conditions [7]. Furthermore, going by [8], due to its low carbon content, it is neither completely ductile nor brittle, with lower malleability and tensile strength. The metal becomes more brittle as the carbon content rises. From the works of [9], a major concern in engineering applications is the failure of machine parts due to stress. Material properties, however, can be improved upon with various techniques, some of which include carburization and heat treatment for some metals [10]. However, according to [11], the inclusion of scarce metals is an intriguing method of microstructural control. It is necessary to have a resistance to wear and a nice finishing surface [7]. Carburizing, usually followed by quenching and, in some cases, tempering, is the undisputed heat treatment technology for raising the hardness, wear resistance, strength, fatigue strength and load carrying capability of metal and, in particular, steel components [12]. For instance, addition of Nickel to grey cast iron improved the wear properties in its use as brake pad [13]. These techniques are currently in large scale use [14]. Carburizing has been found to stably impart high functions like high toughness, great strength, high abrasion resistance with high productivity [15]. Other methods like cladding give a good combination of wear resistance, hardness and tensile strength [16]. Lower destabilization temperatures resulted in optimal mechanical properties, while increasing temperature reduced wear resistance and hardness [17]. Also, according to [18] when Vanadium is added to high

Chromium white Cast Iron, it is suited for production of coal pulverizer as a result of its higher hardness. According to [19], particle organization is a technology which encompasses several fields and disciplines. The contemporaneous internet diagnosis of droplets, bubbles, particles that are solid have been used widely in several areas. Very key to particle characteristics monitoring and control is efficient particle size distribution. How the size is distributed is by far the most important characteristic. It is the driving factor for the standard, safety and efficiency of the finished product [20]. From the work of [21], the particle distribution and solidification rate of cast irons are the two most essential elements that decide the production of several microstructural phases. Going by the works of [22], ImageJ maintains a very firm position as it is in the public domain (meaning that its source code is easily available and its use is unrestricted). It also works on major operating systems in the market and it is also an open-source image analysis software for materials' processing [23].
This research focus on the analyses of material characterizations using microstructures and ImageJ software to understand the pattern of particle size distribution after the carburization process.

Section snippets

Materials and method

HT250 grey cast iron was obtained from scrap metal and chemical composition was carried and the result is shown in Table 1 below. Also, palm kernel shell was obtained and pulverized to about 75 µm size. More so, muffle furnace was deployed for the carburization process at a constant temperature of 950 °C at 30 min interval until to about 180 min. Scanning electron microscope was then used for the microstructural characterization while ImageJ software was later deployed in the analyses of the

Results and discussions

- a.
  Sample A
  Sample A was carburized at 950 °C for 30 min. The SEM image Fig. 2 shows generally a surface which has little effect from carburization. This aids in determining the integrity of the HT250 gray cast iron material after it had been exposed to heat for 30 min. Further analysis of the SEM image using ImageJ yielded the following results; Intensity threshold Fig. 3 with sparse dark areas indicating that the sample barely felt any penetration depth of the carbon additive. Also, surface plot

Conclusion

The study focused mainly on the carburization and characterization of grey cast iron by using pulverized palm kernel shell and ImageJ. From the results, it was observed that several Images resulting from the ImageJ plots revealed the particle sizes and the behavior of the behavior of the particles indicating that different holding time of carburization would result in varying depth of carbon penetration as well as size distributions. These results are vital for the various applications of the

CRediT authorship contribution statement

Enesi Y. Salawu: . **Asoro O. Elvis:** Formal analysis. **Oluseyi O. Ajayi:** Supervision. **Samson O. Ongbali:** Methodology. **Sunday A. Afolalu:** Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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