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The Development of Material Grinding Ball in Ballmill Made of White Cast Iron and Applied to Cement Plants

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***Abstract*—Cement is one of the main ingredients of civil construction. In addition to Indonesia's domestic cement production, cement production is also to meet overseas demand. Cement demand which continues to increase in production costs due to rising costs. The relatively high increase in production costs directly affected the increases in cement prices on the market so that it was necessary to increase efficiency on all lines. Efficiency that can be done is by increasing local components in the process of making cement, including the material used. The purpose of this final project research is to develop materials that can later be used as a reference for making prototype ball mill liners so that later they can substitute imports abroad and can produce their own domestically and compete with imported products. Development of material for prototype liners in ball mills uses white cast iron material through a casting process. This development aims to make white cast iron material for ball mill liners which have physical and mechanical properties in the form of high impact and hardness needed to be able to produce domestically. The chemical composition of imported white cast iron material is C = 2.55%, Si = 0.75%, S = 0.013%, P = 0.018%, Mn = 0.56%, Ni = 0.05%, Cr = 16.17%, Mo = 0%.**

Keywords—white cast iron, ballmill liners, material development component

I. INTRODUCTION

Cement is one of the main materials of civil construction. Indonesian cement production in addition to meeting domestic cement needs, also to meet demand from abroad. The growing demand for cement should be anticipated by the cement industry as production costs continue to rise due to rising electricity base tariffs and domestic oil prices that are not comparable to the increase in cement selling prices in the market. The increase in production costs is quite high directly impacting on the increase in cement prices in the market so that there needs to be increased efficiency in all lines, especially in the production process so that the selling price of cement can remain affordable to consumers in the country and can compete with cement products from abroad. The efficiency that can be done is among others with the development of materials used for the cement plant equipment [1].

Indonesia has a lot of cement plants to fulfill the demand of cement required for constructions (buildings, roads, bridges, etc.) throughout the country. The need of ball mills to produce fine grain cement is unavoidable. They require hundreds tons of grinding balls and liners in order to produce large volume of cement each year. A material of grinding balls and liners requires good mechanical properties such as high impact strength, high hardness strength, and high wear resistant to overcame high impact load during crushing process. Most of the plants are importing the material from other countries such as India, Spain, and China to operate their ball mills. This results high material cost and noncompetitive price for their product.

One of the important components of the ball mill is the liner which consists of different types depending on which stage the liner is used in the cement process. Liner is located in the surface layer of the ball mill machine, the liner is made of metal that is required to have hard characteristics (wear resistant) as well as tough (not easy to crack) and corrosion resistant to bear the load and environment during the rock milling process [1,2].

Cast iron is an alloy metal consisting of an element of iron (Fe) with a carbon element (C). The carbon content (C) in cast iron is above 2.1 %. The carbon is in the form of graphite that has bitter properties. However, not all types of cast iron have graphite, one of them is white cast iron where it almost has the same properties as high carbon steel [3].

This research aims to develop white cast iron material which is later expected to be used to make a prototype of grinders and liners of ball mill which can be produced domestically through the casting process and heat treatment process. The reference material in this study is imported white cast iron material with chemical composition of C=2.55%, Si=0.75%, S=0.013%, P=0.018%, Mn=0.56%, Ni=0.05%, Cr=16.17%, Mo=0%.

II. RESEARCH METHODS

The experimental design of the research is described in the flowchart described figure 1 bellow.

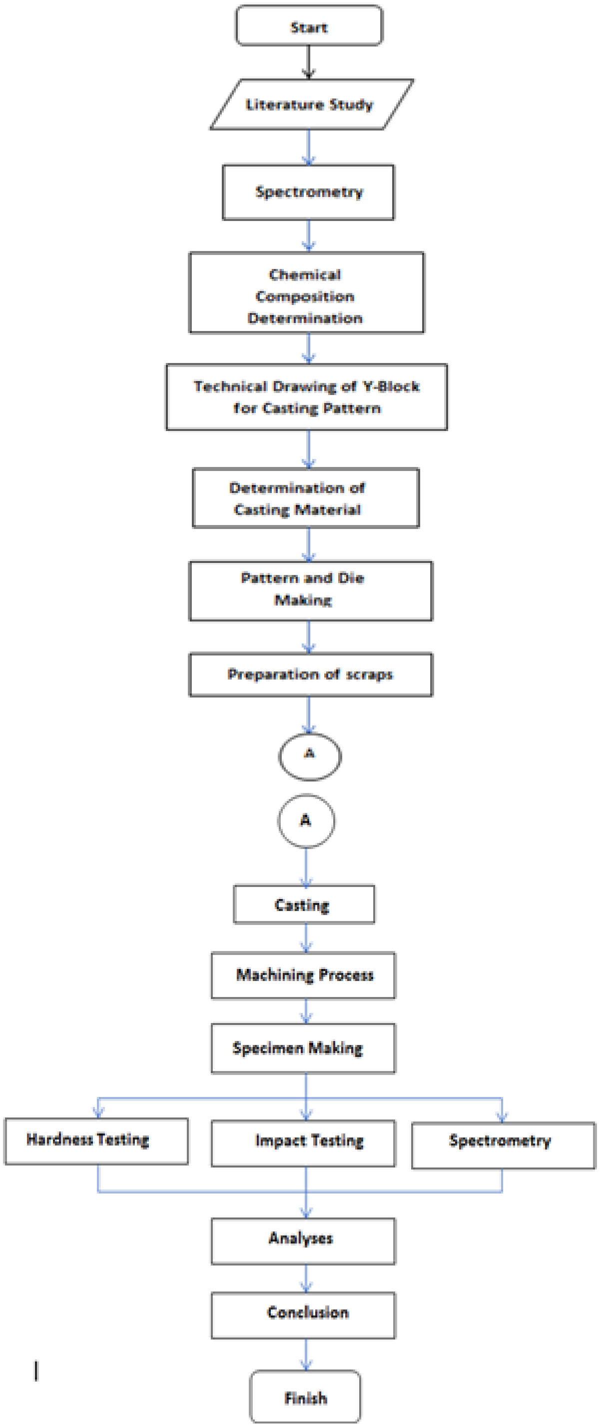


Fig. 1. Flowchart of the research.

The first step is to study the imported materials used for ball grinding and liners to determine their chemical composition by means of Spectrometer testing. After spectrometer testing was conducted it is known that the material used in the imported grinding balls and liners contain carbon (C) above 2.1%, it can be concluded that the material belongs to the category of White cast Iron. The second step is to conduct a casting process with 2 types of chemical composition, namely with Cr content of 1.5% and 2.5%. Then conduct tests in the form of hardness tests, impacts and microstructures test to see the characteristics of the material. The hardness test was carried out by using Brinell Hardness Tester (ASTM E-18) and the impact test was conducted in impact testing machine (Type Galdabini 500).

After that the specimen was heat treatment with a temperature of 850°C with oil quenching for 15 minutes, as well as tempering 500°C for 1 hour which serve to improve the mechanical properties of the material [4]. The heating process was carried in induction furnace type OFENBAU CW-223.

III. RESULTS AND DISCUSSION

The chemical composition of the specimens with low chromium content resulted from the casting process are presented in table 1.

TABLE I. CHEMICAL COMPOSITION OF THE SPECIMENTS

Elements	Chemical composition 1 (%)	Chemical composition 2 (%)
C	3,2	2,1
Si	0,8	0,7
S	0,1	0,08
P	0,07	0,07
Mn	0,2	0,1
Ni	-	1,5
Cr	2,5	1,5
Cu	0,1	-
Zn	0,1	-
Mo	-	-
Co	-	0,17

The hardness of the materials are presented in figure 2.

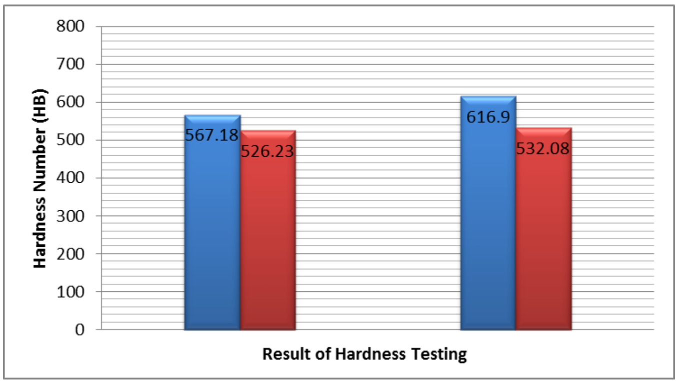


Fig. 2. Hardness testing results of the specimens.

From the figure 2 can be seen the hardness number of the specimen with composition 1 after heat treatment 850°C for 15 minutes with oil quenching is 567.18 BHN, while after tempering process 500°C for 1 hour decreased by 7.22% to 526.23 BHN. The hardness numbers in composition 2 after heat treatment 850°C for 15 minutes with oil quenching value is 616.9 BHN, while after tempering process 500°C for 1 hour experienced an increase of 13.74% to 532.08 BHN. This is because during the process of tempering 500°C for 1-hour carbon is stuck on the FCC wall, causing the stretch to be reduced and resulting in a phase change from martensit to martemper which is more ductile [5].

The Impact values resulted from the impact testing of the materials are presented in figure 3. It can be seen that the impact value for the composition 1 after heat treatment with oil quenching is 2.76 J/mm2, while after tempering process 500°C for 1 hour experienced an impact price increase of up to 3.49% to 2.86 J/mm2. The impact value of the composition 2 after heat treatment 850°C for 15 minutes with quenching oil the value obtained is 2.21 J / mm2, while after tempering process 500°C for 1 hour experiences an increase of 55.71% to 4.99 J / mm2. Because the energy absorbed after tempering process 500°C for 1 hour is greater than the energy absorbed after the oil quenching process.

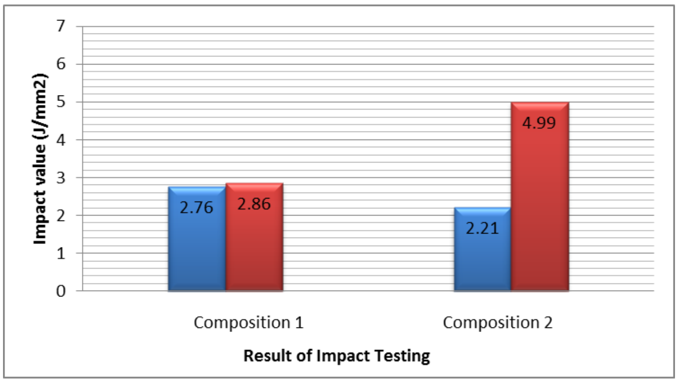
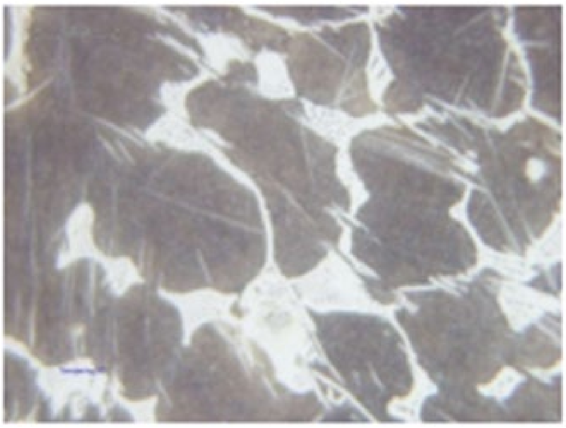


Fig. 3. Impact testing results of the specimens.

This microstructure testing was carried out after the process of hardness testing and impact testing. An etching process or polishing in the form of chemical liquids on the surface was carried out to produce clearer results. Metallography test results of 500°C tempering oil quenching specimens for 1 hour were presented in figure 4.

(a)

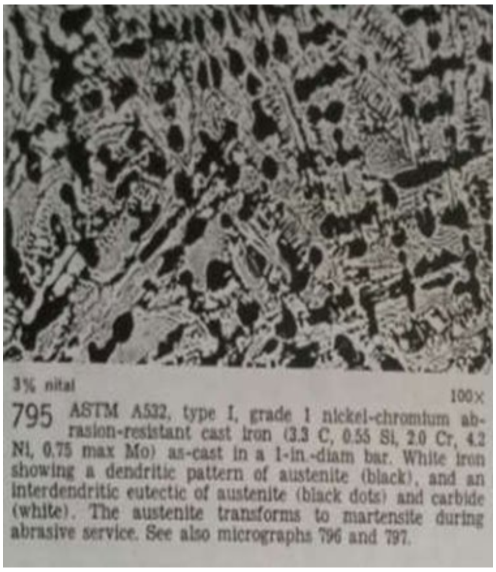


(b)

Fig. 4. (a) Microstructure of the specimen 1, and (b) specimen 2.

The microstructures shown in the figure 4 have simillar pattern with the ASTM Standar pattern shown in the figure 5 bellows [6]. And for specimens 1C and 2C have similarities in literature as in Figure 5, it is mentioned that the carbide is white, the austenite phase is black dot, where the austenitic phase will turn into martensit as an abrasive process occurs.

(a)



(b)

Fig. 5. (a).ASTM Standard of high chromium white cast iron grade III, (b) grade I

IV. CONCLUSION

The chemical composition of the carbon content (C) 3.2% shows that it meets the criteria of white cast which range from 2% - 4%, as well as the lower chromium content (Cr) which is 2.5% compared to imported products that reach 18%. Due to the lower percentage of chromium the developed material can be domestically produced with lower cost.

The value of impact testing after follow-up process in the form of tempering 500°C for 1 hour show higher results than before in tempering, because the higher the temperature the higher the value of impact obtained. Tempering itself is done to reduce residual stress and increase toughness.

Hardness test results for all specimens show a hardness number above 500 BHN. This indicates that the materials developed can meet the hardness standards required by ball grinding and liners on ball mills in the cement industry.

REFERENCES

[1] R. Kartikasari, R. Soekrisno, and M. N. Ilman, “Karakterisasi Ball Mill Import pada Industri Semen di Indonesia,” J. Tek. Mesin, vol. 9, no. 1, pp. 18–24, 2007.

[2] I. Yusri, Material Teknik. Bandung: Teknik Mesin, Institut Teknologi Nasional, 2016.

[3] D. Janicki, “Fabrication of high chromium white iron surface layers on ductile cast iron substrate by laser surface alloying,” Strojniški vestnik-Journal Mech. Eng., vol. 63, no. 12, pp. 705–714, 2017.

[4] K.M. Ibrahim and M.M. Ibrahim, “Heat treatment in high chromium white cast iron Ti alloy,” J. Metall., vol. 2014, 2014.

[5] W.D. Callister and D. G. Rethwisch, Materials science and engineering, vol. 5. John wiley & sons NY, 2011.

[6] T. Lyman, Atlas of microstructures of industrial alloys. Ohio: Metals Park, 1972.