Influence of manufacturing process on wear resistance Of grinding balls

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Abstract

The grinding balls are widely used in cement works, they are often manufactured by the molding process, but the problem faced by major cement plants in Algeria is that these balls wear out quickly and broken. The objective of this work is to test wear resistance of grinding balls made by molding and grinding balls produced by forging. The tests of characterization of samples will be made thus that wear tests. The results indicate that grinding balls made by forging resist longer than molded balls by fact this method offers by fiber-forming phenomenon a solid texture which allows increases service life, wear resistance and impact strength.

Keywords
Grinding ball, forging, molding, texture, wear.

1. Introduction

Raw material grinding facilities use two types of balls; cast iron chrome balls produced by smelters and forged steel balls. These two types of balls differ from point of view of chemical composition and of course from the microstructure point of view. The forged grinding balls consist of an entirely different structure because forging process, under action of a striking force causes a compression and an elongation of grains, thus giving a fibrinous texture and finer. Moreover, this process allows creation of residual stresses which contribute to lifetime of surfaces. Forging allows creation of more resistant parts in impact, fatigue and which is more recommended than all other working methods of metals (machining, welding, and foundry)[1].

The grinding balls operate under severe conditions which combine several wear mechanisms, particularly an abrasive wear [2-4].

The aim of this work is to test resistance to wear by abrasion of grinding balls produced by molding and grinding balls produced by forging.

2. Experimental Techniques

2.1 Materials used

The samples in this study come from two different manufacturing processes. One sample is obtained by molding; the second is obtained by stamping (Figure 1); they are identified as follows:

- Sample No. 1 corresponds to ball made by molding
- Sample N ° 2 corresponds to ball made by stamping

Figure 1. A) ball obtained by molding, B) ball obtained by forging

The chemical analysis of samples was carried out by spectrometry. The analysis results are shown in Table 1. This is a high-chromium cast iron sample intended for production of grinding balls. The second sample is steel intended for forging. These two materials solidify in two different systems. The chromium cast iron solidifies according to Fe-Cr-C system. On other hand, steel solidifies according to Fe-C system.

Table 1. Chemical composition of Samples 1 and 2

Chemical elements	Sample N ° 1	Sample N ° 2
C	1.91	0.447
Mn	0.42	0.59
Si	0.74	0.32
P	0.005	0.003
S	0.005	0.031
Cu	0.047	0.208
Al	0.006	0.027
Ti	0.009	0.002
Nb	0.005	0.002
Ni	0.11	0.099
Cr	19.76	0.159
Mo	0.018	0.049
V	0.042	0.001
Sn	0.004	0.021
B	/	0.000
Fe	76.58	98.0
N	0.36	/
Co	0.02	0.002
W	/	0.012
Pcm	/	0.512
Ceq	/	0.61

Samples were cut and prepared according to conventional method of preparation by using abrasive papers of various particle sizes to finish with diamond paste. Subsequently the polished samples were attacked by nital at 3%.
The micrographs of samples studied were carried out on electron scanning microscope of type Zeiss EVO MA25 (Figure 2).

Figure 2. Electron scanning microscope of type Zeiss EVO MA25.

The MEB micrographs of samples studied (cast iron and forged steel) are presented in figures 3 and 4. The microstructure of chromium cast iron reveals presence of a martensitic matrix and a network of eutectic carbide of M_7C_3 type (Figure 3). This type of cast iron solidifies according to Fe-Cr-C system. The solidification begins with precipitation of primary austenite which continues with decrease of temperature up to eutectic transformation temperature where an aggregate consisting of eutectic austenite and eutectic carbide takes place. In raw casting state, structure consists of an austenitic matrix and a network of carbide M_7C_3. After thermal treatment (quenching and tempering), matrix is transformed mainly into martensite with presence of a proportion of residual austenite. The eutectic carbides remained stable because they are not affected by temperature of heat treatment. Fine pigments appear clearly on matrix. They are derived from heat treatment and represent secondary carbides of M_7C_3 type. This latter contribute strongly to strengthening of matrix.

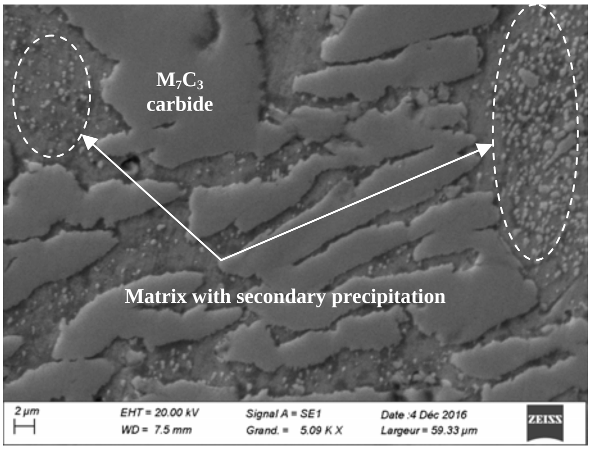

Figure 3. Microstructure of sample N° 1

Figure 4 illustrates MEB micrograph taken on forged carbon steel sample. This microstructure reveals a ferrite-pearlite matrix with presence of some inclusions. The grains are compressed with a fine structure, this is due to forging phenomenon which transforms coarse grains into a fine and elongated shape constituting a fibrinous texture.

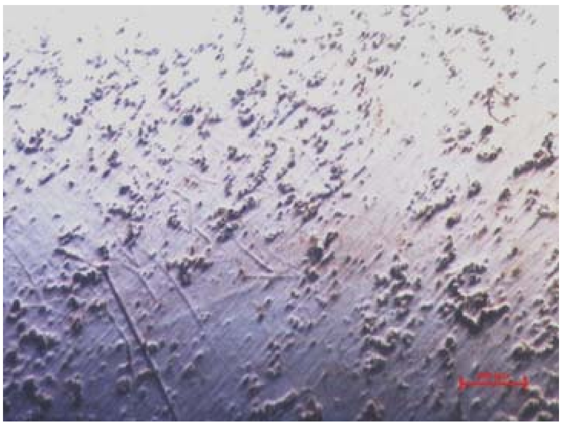

Figure 4. Microstructure of sample N° 2

2.2 Hardness

Rockwell hardness test was carried out by means of an INDENTEC durometer (Figure 5) with a load of 100 Kgf and ball of diameter 1/16 mm. The results of measurement are shown in Table 2.
Equation numbering is optional.

Figure 5. Durometer INDENTEC

Table 2. Measurement of HRB hardness of samples (1.2)

N° of sample	Sample N ° 1	Sample N ° 2
HRB hardness	115.05	111.5

Hardness measurements taken on samples studied are presented in table 2 indicating that chromium cast iron is harder than forged steel. This can be explained by fact that structure of cast iron is of martensitic character as well as presence of very hard primary carbides of type M7C3.

2.3 Wear test

Wear tests were carried out using a device of the type MECAPOL P320 (Figure 6) And a SCALTEC model scale (Figure 7). The test was carried out under the following conditions:
V = 100trs / min, Range = 500m, T = 3min for 100m, load applied p = 12 DN

Figure 6. Wearing device

Figure 7. Weighing machine

3. Interpretation of wear results

The friction wear test results on samples studied are shown in FIG. on this latter, wear is represented by a loss of weight as a function of a distance traveled. It is apparent that chromium cast iron exhibits a lower resistance to wear compared to that of forged steel. It is noted that loss of mass recorded by chromium cast iron is considerable compared to that of forged steel. Latter shows a slight loss of mass due to removal of peaks present on surface and then mass remains almost stationary, which is similar to a running-in.
These two materials (cast iron and forged steel) have different structures: cast iron consists of a structure composed of a ferrous matrix and a network of eutectic carbide M7C3. On other hand, structure of forged steel is completely Ferrous (Figure 8). As a result, these two materials react differently to wear stress used.

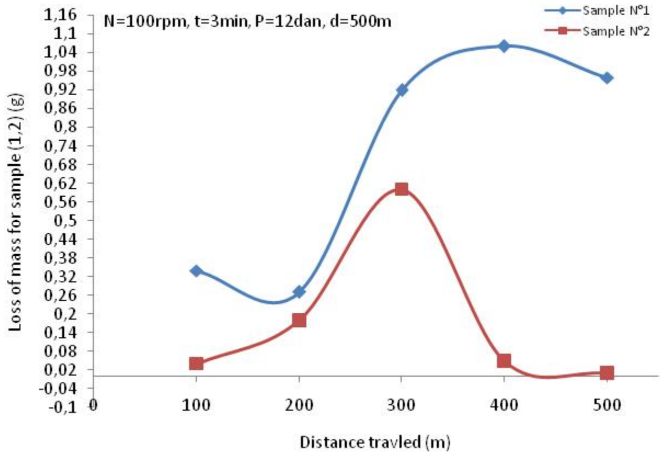

Figure 8. Wear behavior of samples 1 and 2

Detailed microscopic analyses of abrasion wear facies of samples (1, 2) shows small breaks of the material for chromium cast iron due to high hardness of carbides present in matrix (Figure 9). For facies of forged steel, a stacking of layers (Figure 10) was observed to be located at depth of traces of wear which can be explained by a high repetitive plastic deformation.

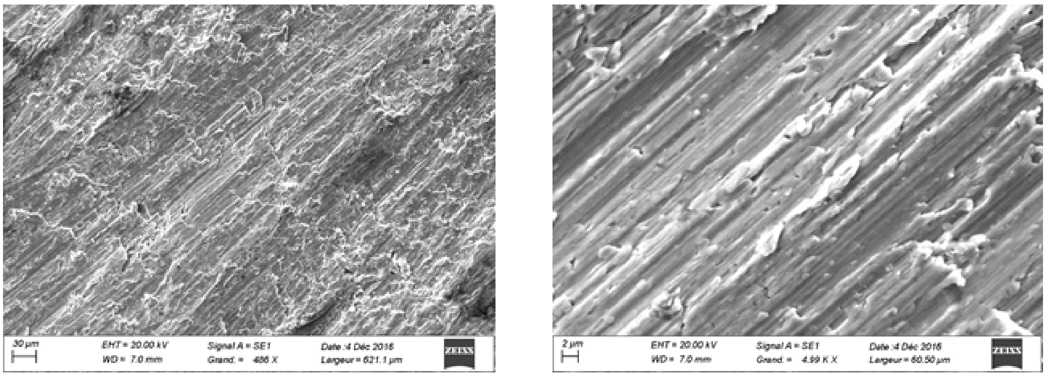

Figure 9. Facies wear of chrome iron

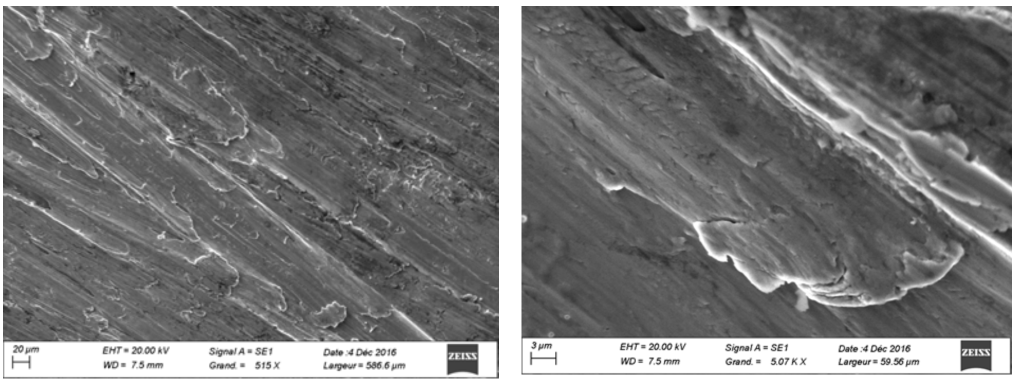

Figure 10. Facies wear of forged steel

4. Conclusion

Forging is an elaboration process which gives material better mechanical and structural characteristics by principle of plastic deformation. Indeed, according to abrasion wear tests, it can be concluded that despite high hardness of cast iron, it is less resistant to wear than forged steel or its fibrous texture makes it more resistant.

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Biography

Mounira Bourebia is researcher in the Welding and NDT Research, Centre (CSC) it work on the project for the simulation of phenomena of breakthrough in continuous casting of steel. PhD student in the laboratory of an affiliated industrial mechanics, university Badji Mokhtar Annaba, Algeria, she obtained her magister integrated manufacturing mechanics in 2010 Badji Mokhtar al university Annaba. She is a member of research team on the surface states. She works under the directives of Professor Lakhder .Laouar, their research focuses on influence of surface roughness condition on a mechanical contact, the processes of mechanical surface treatment, the numerical simulation, optimization and manufacturing.

Dr. Bouhamla khedidja: head of research team at the Research Center in Industrial Technologies CRTI. Our field of interest is based on materials workin on wear condition and iron and steel domains.

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Chaour Mohamed is a searcher attached in the Welding and NDT Research, Centre (CSC) and Temporary teaching in the department of science technology at the Constantine 1 University, Constantine, Algeria. He earned Engineer in Mechanical Engineering Option: Energy from Mentouri Constantine University, Algeria, Magister in Mechanical Engineering Option: Energy applied engineering in the Department of Mechanical Engineering at the Constantine 1 University, Constantine, Algeria. And preparation Doctor in Energy from University of Constantine 1. He has participated conference papers. Mohamed has done research projects with CSC Research Centre. His research interests include energy, simulation, combustion, optimization, Heat transfer, Fluid Mechanics, and Thermodynamics. He is a Mastered technical of Programming in FORTRAN and Simulation software in ANSYS and FLUENT.

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