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Influence of Metallurgical Structure on the Behaviour of Crusher Parts Based Manganese Steels

KEYWORDS: Cone of Crusher, Blow bars, Manganese Steels, Heat Treatment, Chemical Composition, Metallurgy.

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ABSTRACT The blow bar and cone of crusher used in mineral processing are made of Hadfield steel typically containing over 12% manganese. This steel is characterized by a structural change in service caused by hardening. According to the microstructure formed after annealing, the transformation of austenite during the hardening into martensite determines its operating life.
Premature failure of these components is a cause of concern because of the down times and replacement costs.
In this paper, we present the results of the metallographic studies and the analysis of the chemical composition of the various studied samples. We highlight that the haste of carbides in the joints of grains can be considered as a phenomenon favorable to the progress of pre-existent cracks in these areas. This study allowed to develop steel grade manganese can be integrated into the production of blow bar and cone with improved cycle life.

INTRODUCTION

On behalf of their Hadfield inventor, the Hadfield manganese steels or contain a significant amount of manganese, which may in some cases reach 18% manganese [1,2]. The presence of this element confers an austenitic structure in the raw state of development. After a suitable heat treatment, the resulting structure is free from carbides and / or intermediate phases [3].

In operation, the austenitic structure adjacent hardness of 200 HB, undergoes a phenomenon of hardening by shock, and the resulting structure - martensite hardening - higher hardness of 400 HB, allows parts to present a good wear resistance [4]. Austenitic manganese steels combine good ductility with high abrasion resistance.

The point which determines the final properties of the product which must be considered, in particular during the manufacturing process is the chemical composition of the molten steel, followed by a heat treatment to produce an appropriate microstructure and avoid structural defects (space, cracks, inclusions) and fragile phases (carbides).

Therefore, the diverse parameters such as the elements of alloy, the conditions of casting, the speed of solidification of the alloy and cycles of heat treatment can determine the optimal microstructure. Therefore, optimization of these parameters is essential for the production of parts able to withstand shocks. So this article is a contribution to the study of the influence of basic microstructural state performance and the duration of life of parts made of manganese steel, designed to work in an aggressive environment impact, both types parts in this study are the cone and blow bar which are mounted on the said crusher machines.

BASIC PRINCIPLE OF CRUSHER OPERATION

Cone crusher. (Figure 1)

The basic principle of a cone crusher is shown in Figure 1. The main body (concave), mantle (shield) and eccentricity together, form the chamber geometry of the cone crusher. Similar to a crank, the eccentricity turns the main shaft with constant speed. At the top, the main shaft is swiveling in a pivot point. The shield is fixed to the main shaft and the concave to the crusher frame.

The resulting motion of the shield and main shaft will be a nutating motion, in which case the shield will move cyclically forward and backwards relative to the fixed main body (concave). The failure of these shields usually occurs in the lower part, where the compressive stress field (CSS) due to fragmentation rock material is at its highest level [5].

Volume : 5 | Issue : 12 | December 2015 | ISSN - 2249-555X

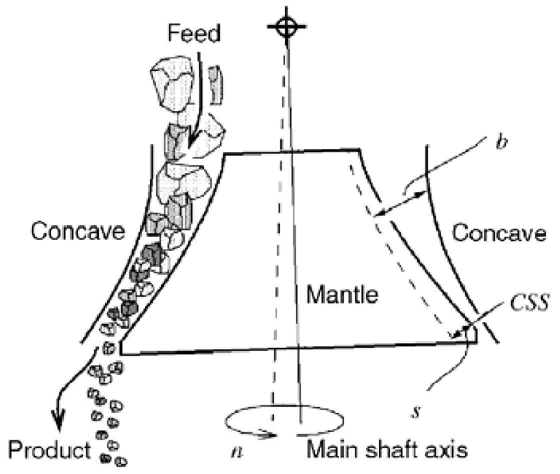


Figure 1 : Schematic of cone crusher basic principle [5].

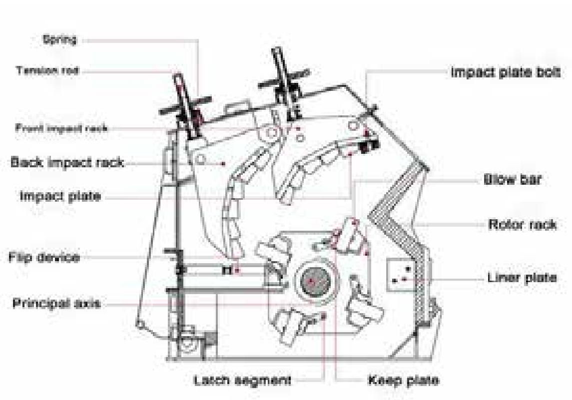


Figure 2 : Schematic of impact crusher basic principle [5].

Therefore, material will be moved recurrently and repeatedly in the crushing chamber that is composed of rotor, impact plate / anvils, hammers/ blow bars, by means of which intense shock phenomenon will act predominantly, and the material will be crushed along its natural crack and hence bulge [5].

EXPÉRIMENTAL METHODS

Cast samples

we have two class parts: cone (made of Z120MC12-1M shade) and blow bars (made of Z120MC17-2M shade), we have prepared 30 samples divided into two groups, the first group (Group.I) present samples taken the reference parts that gave the best results and good duration of life, and the second group (Group.II) has taken samples of the parts with low duration of life.

The alloy used for our experiment was developed in an induction furnace. The alloying elements are added as ferro-alloy. Our experimental study is based on two shades, whose chemical composition is shown in Table 1.

Table – 1

Chemical composition according to NF A32-058

shade	C	Si (max)	Mn	S (max)	P (max)	Cr
Z120M 17-M	1.1-1.4	1	16-18	0,03	0,08	1,8-2,3
Z120MC12-1M	1.1-1.4	1	11-14	0,03	0,08	1-2,5

The sample must be flat, surfaced just before the analysis to avoid oxidation and free from defects. The steel sample preparation machine manganese is a disc resurfacing. Chemical analysis was determined by spectrometry.

Microscopic examination

Metallographic examination has as it main aims that Highlight the different microstructural phases samples of the structure of the sample and non-metallic inclusions during observation under an optical microscope.

Microscopic observation requires precise adjustment of the surface polishing, to obtain a good image representative of its structure. Polishing in our case is obtained manually on a manual polisher with speed of 300 rev / min.

After polishing and finishing some components are visible without etching, but others present in the structure cannot be differentiated only by a chemical attack, which aims to highlight the entire structure, grain boundaries and also allows highlighting the crystallographic orientation. As in our case, it was used as a chemical attack Nital whose concentration is 4% for 1.5 min (at room temperature).

Heat treatments

From a point of view metallographic structure, for this type of steel, we obtain in the development raw material an austenitic structure in which carbides form clusters in areas near the grain boundaries. It is therefore necessary to conduct a heat treatment to enable the dissolution of the carbides in the matrix. Hence, the Heat treatments carried out on this type of metallurgy: heating to a temperature in the range from 1050 to 1100 ° C, maintains the time needed depending on the thickness, followed by cooling with water.

In Figure 3, we can distinguish clearly the contribution of a heat treatment of hypertrempe, which allows the dissolution of carbides and obtaining an austenitic structure clearly identified in the case of a steel-M Z120M12 [3] .

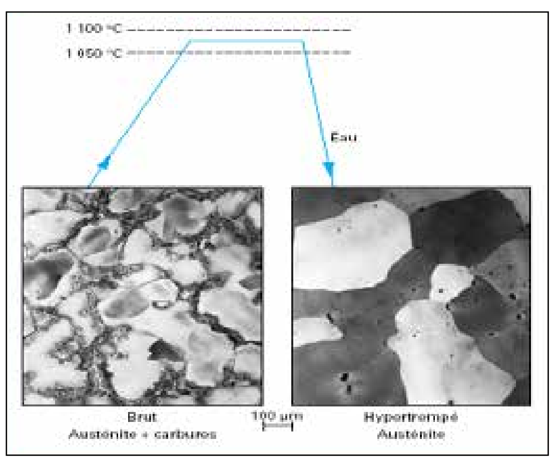


Figure 3: Metallographic structures of steel manganese Z120M12-M before and after heat treatment [3].

RESULTS

Volume : 5 | Issue : 12 | December 2015 | ISSN - 2249-555X

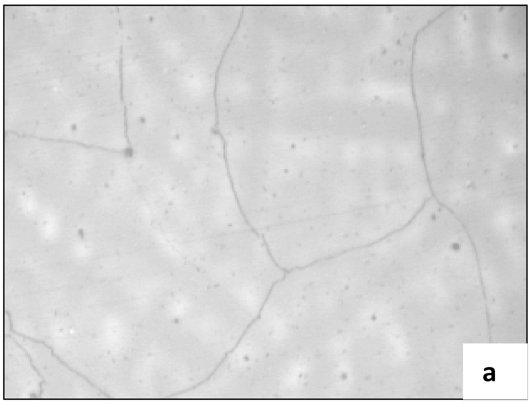
Samples blow bars
Chemical composition Samples blow bars

Table – 2
Chemical composition Samples blow bars

Chemical composition of steels experienced %									
C	Si	Mn	S	P	Cr	Ni	Mo	Cu	
Groupe I	1.03	0.26	15.7	0.02	0.02	2.07	0.22	0.04	0.18
Groupe II	1.04	0.23	15.4	0.02	0.02	2.10	0.23	0.05	0.15

- Chemical analyzes performed on samples corresponding to the range of nuance Z120MC17-2 M given by the NF A 32-058 standard.

***Analyze Metallographic* blow bars**



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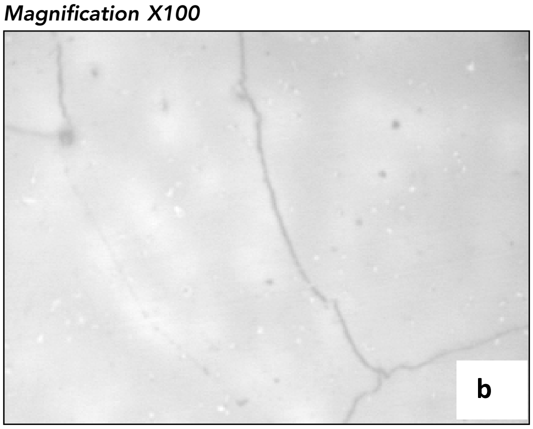

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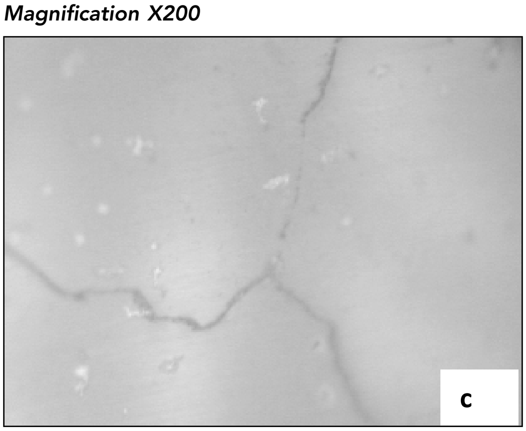

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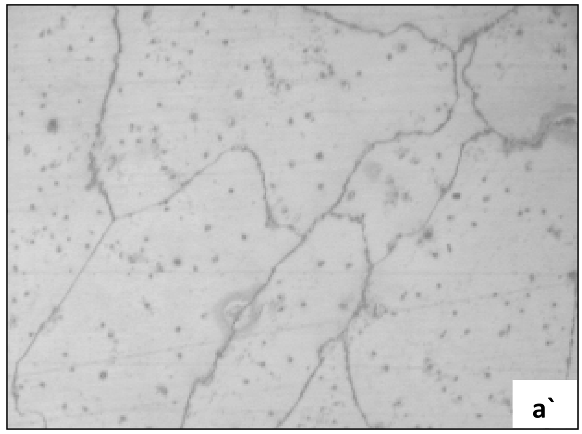
***Resultants Analyze blow bars* (Group I)**

Figure 5: Micrographs Structural blow bars (Group. I)

- Metallographic analysis of the samples (Group.I) shows that there are typical austenitic structures of proper size with clear grain boundaries and clean. Figure 4 (a, b et c)



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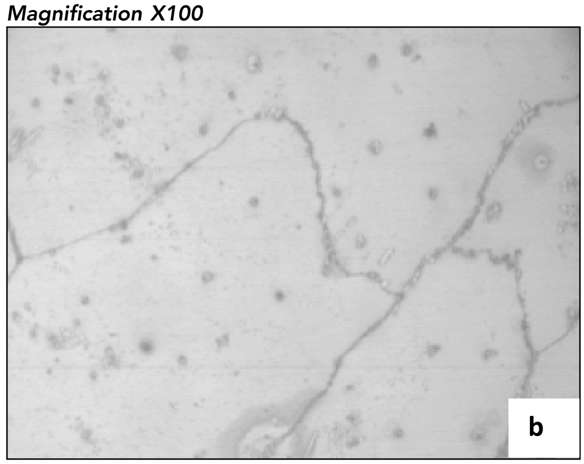

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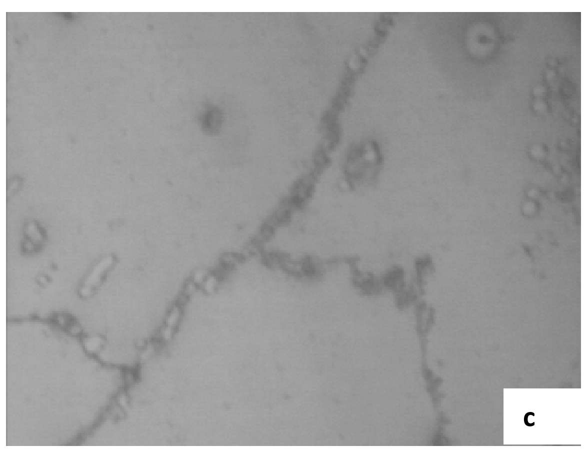

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Figure 6: Micrographs Structural blow bars (Group. II)

Resultants Analyze blow bars (Group II)
-Metallographic analysis of the samples (Group. II) shows that there are an austenitic structure but heterogeneous dimensions, with a distribution of carbides at grain boundaries and even inside the grains. Figure 5 (a`, b` et c`)

Volume : 5 | Issue : 12 | December 2015 | ISSN - 2249-555X

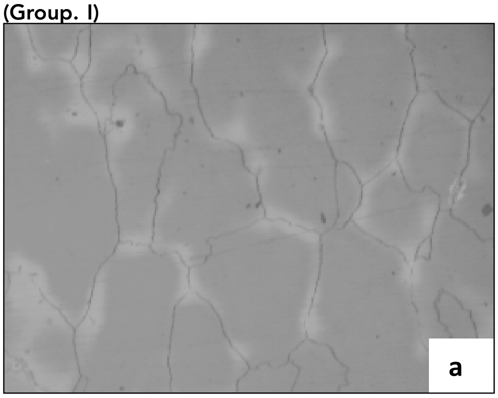
Samples cone .
Chemical composition cone

Table – 3
Chemical composition samples cones

Chemical composition of steels experienced %									
C	Si	Mn	S	P	Cr	Ni	Mo	Cu	
Group I	1.19	0.32	12.7	0.02	0.03	1.21	0.44	0.10	0.28
Group II	1.15	0.34	11.8	0.03	0.03	1.29	0.13	0.10	0.28

- Chemical analyzes performed on samples corresponding to the range of nuance Z120MC12-1M given by the NF A 32-058 standard.

Analyze Metallographic cone
(Group. I)



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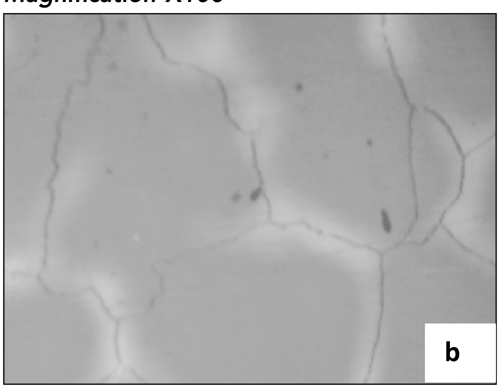

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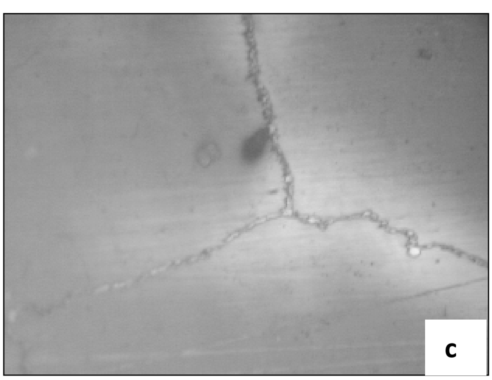

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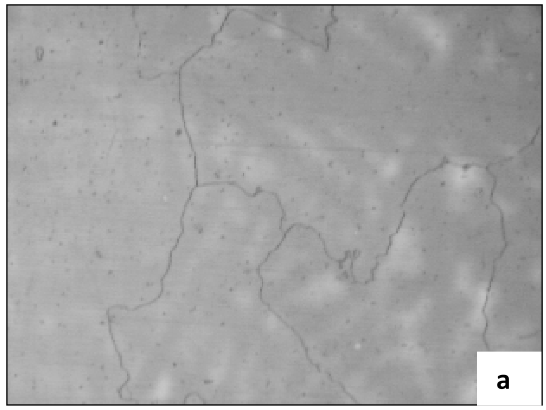
Figure 7: Micrographs Structural Cone (Groupe I)

Resultants Analyze Cone (Group I)

Metallographic analysis of the samples (Group.I) shows a well resolved austenitic structure with a correct grain size and clean. Figure 4 (a, b et c)

(Group. II)



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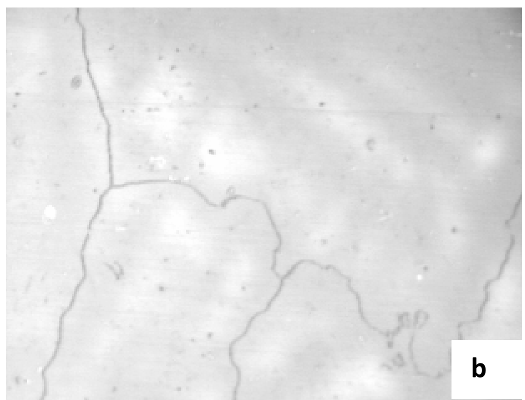

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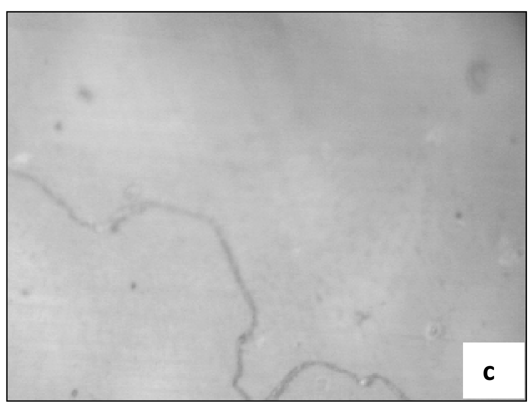

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Figure 8: Micrographs Structural Cone (Group II)

Resultants Analyze Cone (Group II)

- Micrographic analysis of samples (Group.II) shows that it is a resolved austenitic structure but with a heterogeneous size and sometimes presence of carbides at the grain boundaries. Figure5 (a`,b`et c`)

DISCUSSION

We realized a comparative metallurgical study between

Volume : 5 | Issue : 12 | December 2015 | ISSN - 2249-555X

reference parts (Group I) having given better results and good lasted life and (Group.II) parts having low one lasted life.

By means of the metallographic techniques of laboratory, we noticed that reference parts (Group.I) present structures typical austenitics with correct dimensions of grains, and joints of grains exempt from carbides (hard and fragile elements).

On the other hand in the parts (Group.II) having low one lasted life, we noticed that the internal structure is an austenitic (less solved) with dimensions of heterogeneous grains. We observed the presence of carbides on the joints of grains, even though parts underwent a heat treatment.

The results of micrographic analysis on samples (Group.II) taken from parts having low one lasted life for both types cone, and blow bars show that there is a structural problem which can be of the heat treatment :

- Either that the cycle of heat treatment was not respected (the case of heterogeneous dimension of grains [8].

- Either that the mode of cooling is not sufficient to congeal the distribution of carbides in grains.

- Either that the modus operandi of finish and grinding of parts does not take into account thermal gradients, and consequently, additional heat treatments which would have an influence on the final structure of parts.

CONCLUSION

The focus on improving operating properties of Hadfield steel continues to grow. The introduction of different character influenced crystallization, the formation of the micrographic structure. This influence has a net change of use of the main properties resistance to abrasion and lasted life of cone and blow bars .

In group.II, The heat treatment would not have made well according to the rule book, in a lesser effect, the modus operandi of finish of parts does not take into account gradients of the temperatures, what is going to favour the appearance of carbides in the joints of grains.

This study showed that the structure micrographic and heat treatments are influence of life duration of cone and blow bars and resistance to wear very significant.

It is also recommended to avoid the nucleation of internal cracks to make sure one gone up a rather slow temperature and in times of preservation being enough for allowing dissolution complete carbides.

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