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MICROSTRUCTURE AND HARDNESS OF TWO MATERIALS FOR HAMMER OF MILLS

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ABSTRACT
The usual material for the production for hammer of mills is steel cast GX120Mn12 (Hadfield steel). The working life of hammer of mills is 28 to 30 days. In an effort to achieve the longest life expectancy of milling hammer, alloy with chromium was performed (1.5-2.5% Cr). This paper presents a comparative analysis of two hammer materials that showed a significant difference in the microstructure and hardness of the examined samples.
Keywords: steel casting, microstructure, hardness, microhardness, chemical composition

1. INTRODUCTION
The material for hammer mills is cast high-manganese steel known as Hadfield steel. The most important elements in the Hadfield steel are carbon and manganese. Hatfield steel usually containing 1 to 1,5%C and 11 to 14%Mn. This material has got high wear resistance during the operation under dynamic loads, while maintaining good toughness, high-manganese steel castings are widely used in the power industry and in processing of various materials for components of crushers, mills and construction machinery (lining plates, hammers, jaws, cones). In its typical embodiment, this steel in as-cast condition is characterized by an austenitic microstructure with precipitates of alloyed cementite and the triple phosphorus eutectic of an Fe- $(Fe,Mn)_3C$-$(Fe,Mn)_3P$ type which appears when the phosphorus content exceeds 0.04 % [1].

2. AUSTENITIC MANGANESE STEEL CASTINGS
This material due to its chemical composition has austenitic microstructure. Manganese opens γ -field and in alloys with more than 5%Mn austenite does not transform in ferrite by diffusion during the cooling. That means that austenite is transformed by group movement of atom no diffusion is transformed into cubic martensite [2].

2.1. Chemical composition
Standardized chemical composition of austenitic steel cast is given in table 1 [3]. Important note is that the ratio of manganese to carbon shall be not less than 10:1 [4].

Table 1. Chemical composition of austenitic steel cast, [3].

Material	Chemical composition, [wt%]					
	C	Si	Mn	P max	S max	Cr
GX120Mn12	1,0 to 1,4	≤ 1,0	11,0 to 14,0	0,100	0,05	---
GX120MnCr1202	1,0 to 1,4	≤ 1,0	11,0 to 14,0	0,100	0,05	1,5 to 2,5

2.2. Microstructure

Manganese steel casting with more than 1% C and 10% Mn, according to the Guillet diagram, Figure 1 [5], has austenitic microstructure.

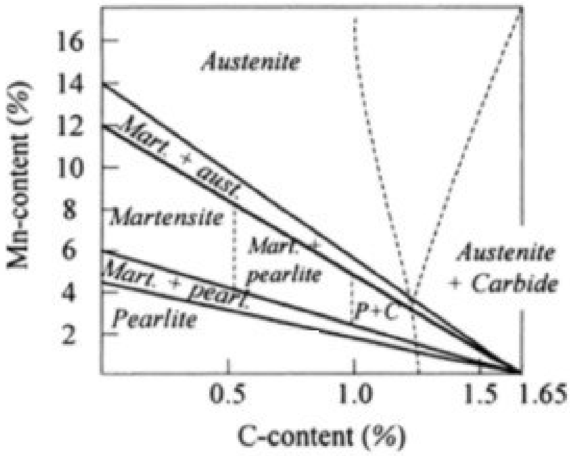


Figure 1. Guillet - microstructure diagram of manganese steel.

The microstructure of Mn-steels is essentially influenced by the carbon content. Carbon content C=1,65% in the diagram basically corresponds to point E of the Fe-Fe_3C phase diagram. The manganese steels in the middle composition range – resulting in a martensitic microstructure which are not used in engineering practice because they have a martensitic microstructure at room temperature even during air-cooling [5].

3. EXPERIMENTAL PART

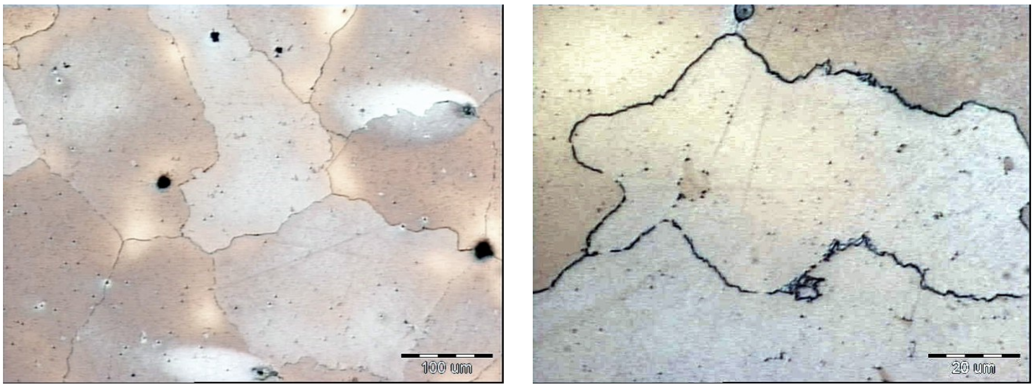
Testing was conducted at two different hammer mill materials. Figures of examined samples are given at figure 2. Chemical composition of examined samples of hammer mills is given in table 2.

Figure 2. Sample of examined hammer mil

Table 2. Chemical composition of examined samples of hammer mills.

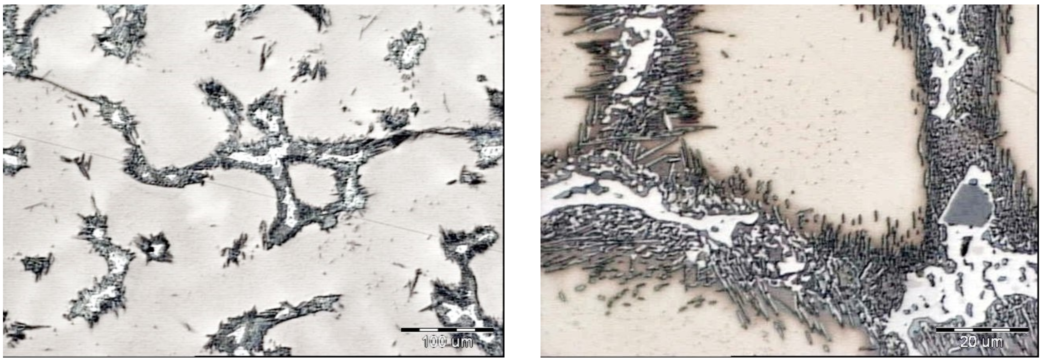
Material	Chemical composition, [wt%]					
	C	Si	Mn	P	S	Cr
Sample 1 (GX120Mn12)	0,90	0,21	10,2	0,037	0,003	0,22
Sample 2 (GX120MnCr1202)	1,39	0,50	11,6	0,056	0,008	2,14

Testing of microstructure is made by light microscopy, magnification 100 and 500. Microstructures of examined samples of hammer mills are given at figures 3 and 4.



a) Magnification 150 x *b) Magnification 750 x*

Figure 3. Sample 1 - cast Hadfield steel austenitic matrix with precipitates of alloyed cementite spread along the grain boundaries; nital etching



a) Magnification 150 x b) Magnification 750 x

Figure 4. Sample 2 - cast Hadfield steel with chromium addition, austenitic matrix with acicular alloyed cementite; nital etching

3.1. Hardness of hammer mills samples

Hardness testing was done in order to confirm differences in microstructure. Results of hardness testing are given in table 3.

Table 3. Results of hardness testing of examined samples of hammer mills.

Mark of samples	Test results *(HBW 2,5/187,5)*		*Mark of samples*	Test results *(HBW 5/750)*	
	Single values	Average		Single values	Average
Sample 1 (GX120Mn12)	224	*218*	Sample 2 *(GX120MnCr1202)*	235	*251*
	215			257	
	215			252	
	219			257	
	215			255	

For purposes of this paper microhardness testing HV0,1 of austenite matrix and undisolved carbides on sample with Cr was conducted. Results of microhardness testing are given at figure 5.

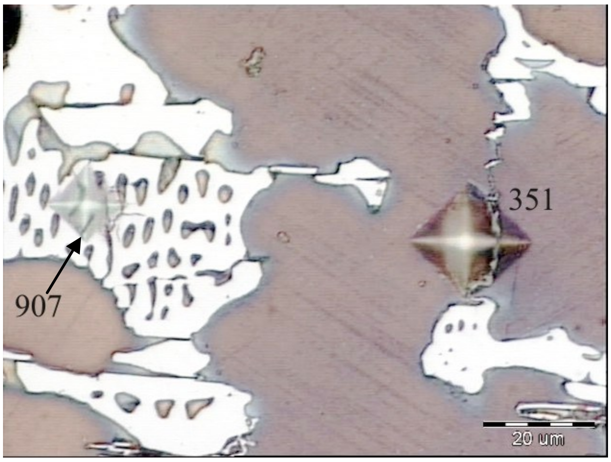


Figure 5. Sample 2 - cast Hadfield steel with chromium addition, microhardness HV0,1

4. ANALYSIS OF RESULTS

Chemical analysis of two examined samples of hammer mills shows that ratio of manganese : carbon is bigger than 10 in sample 1, but in sample 2 this ratio is 8,3. Content of Cr in sample 2 is 2,14% and this examined hammer is alloyed manganese steel casting.

Microstructure of sample 1 is usually austenitic matrix with precipitates of alloyed cementite spread along the grain boundaries, and microstructure of sample 2 is austenitic matrix with acicular alloyed cementite.

Results of hardness testing shows that sample with added Cr has bigger hardness than sample without Cr. Microhardness testing shows that hardness of undisolved carbides is much bigger than hardness of austenite matrix.

5. CONCLUSION

The comparative analysis of two hammer materials showed a significant difference in the microstructure and hardness of the examined samples. Microstructure of Hadfield steel alloyed with chromium is austenitic matrix with alloyed acicular carbides (cementite) and hardness is bigger than in material without Cr. Differences between microhardness in carbides and austenitic matrix in chromium alloyed hammer mill can be the reason for faster wear of these hammers. Examination of working life of hammer mills and prolongation it more than 30 days can be explored in further work in cooperation with heat plants and etc.

6. REFERENCES

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