CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

OTTAWA

MINES BRANCH INVESTIGATION REPORT IR 58-185

EXAMINATION OF FRACTURED MANGANESE STEEL, ROCK CRUSHING HAMMERS

by

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COPY NO. 23

OCTOBER 20, 1958

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SUMMARY

Three samples of broken, manganese steel hammers were examined to determine the cause of failure. Chemical analyses showed the three samples to contain 1.37% to 1.47% carbon and 1.67% to 2.06% chromium. Phosphorus contents ranging from 0.068% to 0.081% were also reported. Metallographic examination showed the presence of a large amount of undissolved carbide, and it was decided that the composition made it difficult to heat treat the castings properly, and was therefore the cause of the trouble.

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(1 table, 2 illus.)

INTRODUCTION

Three fractured manganese steel rock crushing hammers were received at the Physical Metallurgy Division on August 25, 1958, along with a request to examine the samples in order to determine the reason for the failures. The covering letter dated August 20, 1958, from Mr. R.K. Motherwell, Sales Manager, Foothills Steel Foundry and Iron Works Limited, stated: "We suspect that our chromium addition to the manganese steel was all right until we started running slightly higher carbon contents to prevent mushrooming in crusher jaws".

CHEMICAL ANALYSES

Drillings were obtained from each of the three samples supplied for chemical analyses. Table 1 lists the results obtained.

Table 1

Analyses of the Three Samples

Element	Hammer "A" %	Hammer "B" %	Hammer "C" %
C	1.47	1.37	1.46
Mn	13.33	13.16	12.50
Si	0.61	0.60	0.52
S	0.010	0.008	0.008
P	0.080	0.068	0.081
Cr	1.74	2.06	1.67

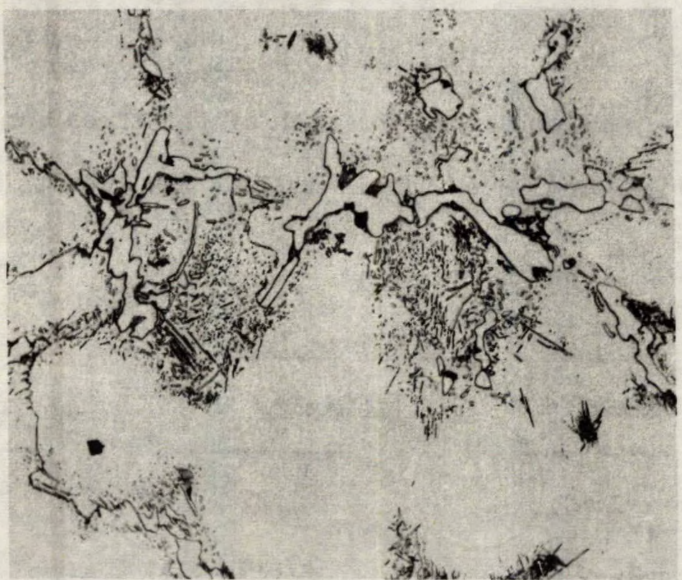
HARDNESS TESTS

Samples were cut from each of the three hammers, and after suitable preparation, microhardness surveys were performed. These showed that two of the three hammers had work-hardened to over Rockwell "C" 50 to a depth of about 0.040 in. The third hammer, however, had a surface hardness of only Rockwell "C" 44, and this dropped to Rockwell "C" 33 at a depth of 0.050 in. below the surface.

Brinell hardnesses were obtained away from the worked surfaces of each of samples marked A, B and C. These were 255, 241 and 241 BHN* respectively.

METALLOGRAPHIC EXAMINATION

Examination of polished and etched samples showed each of the three hammers to contain large amounts of both grain boundary and massive carbides as shown in Figures 1 and 2.



(Etched in 6% nital; X150)

Fig. 1. - Field from sample "A" showing large amounts of carbide.

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* 241 BHN corresponds to Rockwell "C" 22.

(Etched in 6% nital; X150)

Fig. 2. - Shows intercrystalline path of crack in Sample "C".

DISCUSSION

The analyses of the hammers are such that it would be difficult to correctly heat treat the castings. The quantity of carbides that would originally be in the castings increases with carbon content, and the chromium content acts to make these carbides more thermally stable. Consequently, a very high heat treating temperature, coupled with an extended soaking period, would be required in order to obtain a completely austenitic structure in these hammers when water quenched.

The high phosphorus content is another undesirable feature shown up by the analyses. Although not believed to be a cause of failure in this instance, it has been shown that the susceptibility of manganese steel to hot tearing increases with increasing phosphorus contents, especially when above about 0.060% phosphorus. Consequently, this is a potential source of trouble in other castings if it is allowed to go unchecked.

The large amount of plastic deformation that manganese steel undergoes when it is subjected to impacts, (mushrooming) is a big problem with manganese steel parts. Although a higher initial hardness (after heat treatment) reduces the amount of plastic deformation, too high an initial hardness can cause heat treatment difficulties such as encountered with these samples, as the higher initial hardness can only be obtained by increasing either the carbon or the alloy content. Consequently, a compromise is the usual partial solution to both troubles. A composition which may prove of some help would be:

Carbon	1.30% max.
Manganese	12.5 to 13.5%
Silicon	1.00% max.
Phosphorus	0.060 max.
Chromium	1.50 to 1.80%

A heat treating temperature of 2050°F is recommended for the above analysis, along with a sufficient time at temperature for complete solution of the carbides.

CONCLUSIONS

(1) The carbon and chromium contents were such as to make proper heat treatment of the castings difficult.

(2) All three samples contained large amounts of both grain boundary and massive carbides.

(3) The phosphorus contents were all high. This element is not believed to be associated with the failure in question, but could be a possible source of trouble if not corrected.

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