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METALLURGICAL EXAMINATION OF AUSTENITIC MANGANESE STEEL CRUSHER CONCAVES

by

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SUMMARY OF RESULTS

Examination of crusher concave samples of manganese steel from the bottom three rows of a cone-crusher indicated the compositions to be similar to that specified. All samples contained grain boundary carbides and samples from row 4 contained undissolved massive carbides, and correlated with a higher incidence of breakage reported for that row. It was suggested that if plastic flow was unimportant a plain austenitic manganese steel should be used. If plastic flow was of concern, then an addition of 2% molybdenum would be preferable to the $1\frac{1}{2}$% chromium addition used in these castings, as a means of increasing the yield strength without causing increased difficulty in heat treatment.

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INTRODUCTION

Three sets of samples submitted by the Iron Ore Company of Canada, Labrador City, Newfoundland, representing the bottom three rows from a manganese steel crusher, were sent to the Physical Metallurgy Division for examination. The covering letter stated that this last set of crusher concaves gave 80% of the expected service life as judged by the average obtained over the last four years. Specifically, answers to the following three questions were requested.

1) Is the composition comparable to the typical one.

2) Were the heat treatments correctly done.

3) Should we stay away from that alloy and confine ourself to standard manganese steel and/or manganese - 2% molybdenum steel.

The wear pattern encountered in the crusher was supplied in both plan and sectional views, along with comments on concave rows 4, 5 and 6, for which samples were supplied. A note was also included in the covering letter which stated -- "Quite a few of the shovel teeth and adaptors went through the crusher and are the "cause" of the broken ones. Maybe not as many went through before but it is the first time that the breakage is so severe."

CHEMICAL ANALYSIS

Drillings were obtained from the six samples supplied, (two from each of rows 4, 5 and 6) and analyzed chemically. These results are listed below in Table 1, along with a typical analysis supplied by Sorel Steel Foundries for their Alloy SSS-18. The Brinell hardness of some samples is also listed in this table.

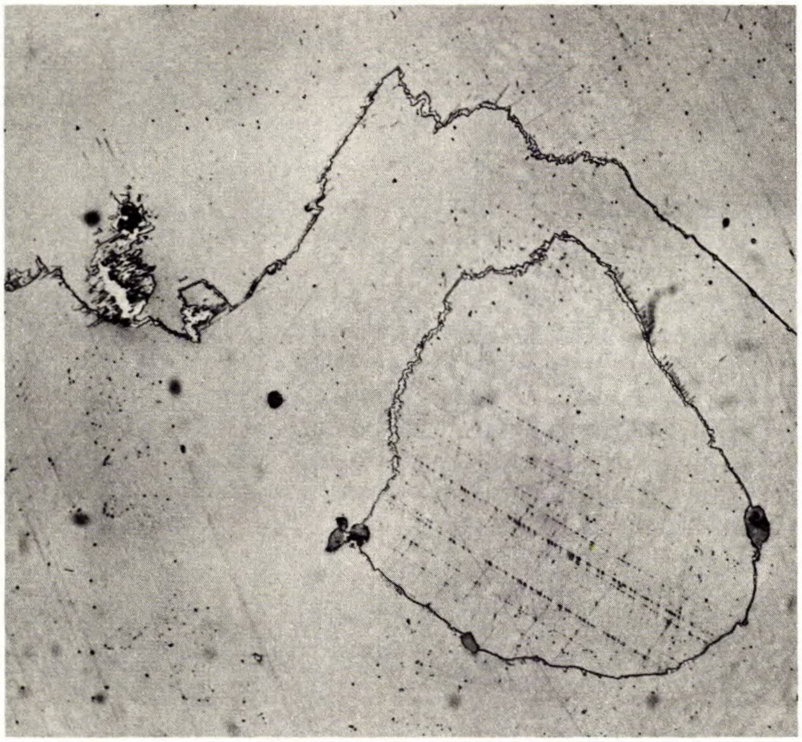
TABLE 1

Analysis of Supplied Samples and Hardness

Element	Composition (%)						
	4A	4B	5A	5B	6A	6B	Typical
C	1.09	1.40	1.28	1.20	1.24	1.29	1.0/1.3
Mn	13.40	13.31	13.03	12.96	12.89	12.76	13.0
Si	0.66	0.64	0.47	0.56	0.54	0.47	0.60
S	0.013	0.012	0.011	0.013	0.012	0.013	0.020
P	0.058	0.054	0.054	0.058	0.055	0.049	0.045
Cr	1.35	1.34	1.45	1.48	1.47	1.47	1.80
BHN	331	311	--	229	--	229	210/230

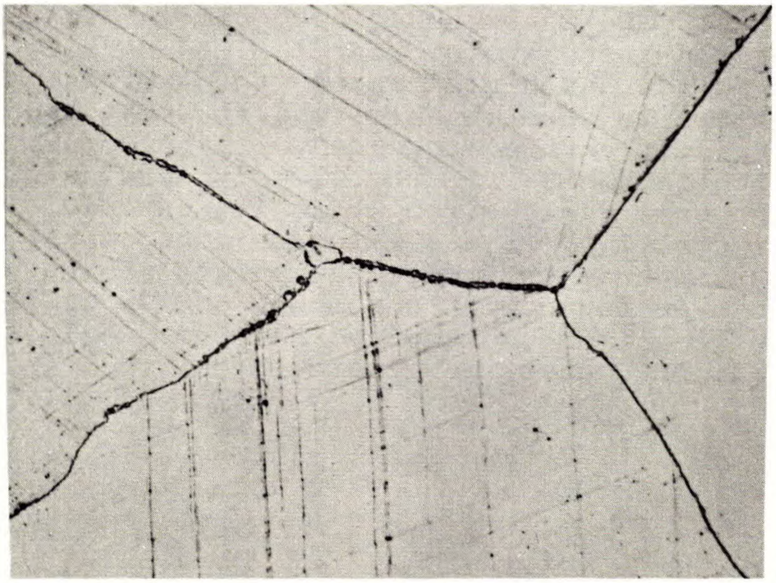
METALLOGRAPHIC EXAMINATION

Samples were cut from several of the samples and examined under a microscope after suitable preparation. In general, the samples representative of row 4 contained considerable amounts of both grain boundary and massive or free carbide, as might have been anticipated from the hardness figures. Samples from rows 5 and 6 contained varying amounts of grain boundary carbide, but no free carbide was observed. Figure 1 shows the carbide present in the sample from row 4, while Figure 2 is a typical field which would be representative of the microstructures in samples from rows 5 or 6.



Mag. X500 Etched in 6% nital

Figure 1. Photomicrograph of area representing sample 4A showing grain boundary films of carbides as well as free carbide. Carbides of this nature were present throughout the sample examined.



Mag. X500 Etched in 6% nital

Figure 2. Photomicrograph of area from sample 6. The grain boundary carbide shown here is typical of that found in sample 5. Very little free carbide was found in either of samples 5 or 6.

DISCUSSION

The samples from row 4 showed the presence of extensive amounts of undissolved carbides, and the supplied comments indicated the greatest breakage to have occurred in this row, which is consistent with our findings. It is interesting to note that both samples examined from row 4 concave had similar amounts of carbide in their structure despite the fact that the carbon contents were at the two extremes of the six samples analyzed, i.e., 1.09% and 1.40% carbon. This indicates that faulty heat treatment is the prime cause of the carbides, and not compositional variations. Also, the hardness appears to be a useful means of ascertaining whether or not free carbide is present.

The presence of grain boundary carbide in all samples examined indicates either the austenitizing temperature was too low, the soak time too short or the cooling rate from the austenitizing temperature too slow.

In general, chromium additions to manganese steel will necessitate higher austenitizing temperatures and/or longer soak times to completely dissolve all carbides. The quench rate is also important, and heavier sections such as encountered here, make this operation even more critical. The main reason for the addition of chromium to austenitic manganese steel is to raise the yield point, which in turn reduces the amount of plastic flow in service. The as-quenched hardness is also somewhat higher, and could increase the wear resistance slightly. If plastic deformation can be tolerated, the usefulness of the chromium addition is questionable, and as pointed out, the heat treatment difficulties are increased with chromium. If reduced flow in service is necessary, the 2% molybdenum addition would give about the same yield strength as $1\frac{1}{2}$% chromium, and should not alter the ductility of the alloy as much as the chromium. Also, molybdenum tends to produce globular type carbides, rather than the film type found with chromium, and so the cracking tendency resulting from undissolved carbides would be reduced. The cost would, of course, be greater.

CONCLUSIONS

1) The compositions of the samples submitted were similar to the supplied typical analysis. The chromium was slightly lower, but not sufficient to cause concern.

2) The heat treatment was faulty for the samples examined from concave row 4, and was borderline for the other samples supplied. In general, either a higher austenitizing temperature, a longer soak period, or possibly a faster cooling rate would be required to obtain a fully austenitic steel. It is likely that either of the first two suggestions would solve the difficulty.

3) In general, the use of 2% molybdenum appears to be preferable to 1½% chromium, if a manganese steel with reduced plastic flow is required. If plastic flow can be tolerated, unalloyed austenitic manganese steel should be used.

RKB/sg