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CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

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MINES BRANCH INVESTIGATION IR 58-192

EXAMINATION OF A DEFECTIVE AUSTENITIC MANGANESE STEEL 5 1-2 FT. BOWL LINER

by

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PHYSICAL METALLURGY DIVISION

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R.K. Buhr*

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SUMMARY

An investigation has been carried out on a 5½ ft austenitic manganese steel bowl liner which cracked in service. The cause of the cracking is believed to be due to a large grain size and the presence of grain boundary carbides. Lower pouring temperature and a more careful heat treatment were the remedial steps recommended.

The examination also showed the presence of a high phosphorus content, which was a possible source of future trouble if not checked. It was not, however, involved in the present trouble.

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(2 tables, 2 illus.)

INTRODUCTION

A piece removed from a 5½ ft austenitic manganese steel bowl liner was received at the Physical Metallurgy Division on August 13, 1958. The covering letter dated August 7, 1958, from Mr. R. Desilets, Chief Metallurgist, Sorel Steel Foundries Ltd., stated that the casting had been returned by their customer because of the development of cracks. It was requested that the factors causing the premature failure of the casting be determined.

CHEMICAL ANALYSIS

The analysis of drillings obtained from the casting, as well as the analysis supplied by Sorel, are shown in Table 1.

TABLE 1

Analyses of the Bowl Liner

Element	Sorel Analysis %	Mines Branch Analysis %
C	1.18	1.15
Mn	12.50	13.10
Si	.76	.80
S	-	.010
P	.060	.086
Cr	-	.13

HARDNESS SURVEYS

A microhardness survey was performed on a suitably prepared sample, using a 500g load and a Knoop indenter. Table 2 lists the results, showing both Knoop hardness and the corresponding converted Rockwell hardnesses.

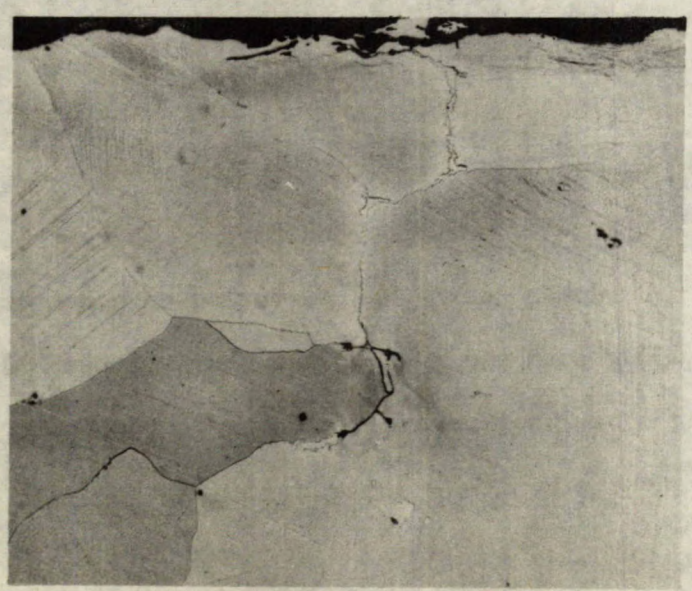
TABLE 2

Microhardness Survey

Distance from Worked Surface Inches	Knoop Hardness Number	Converted Rockwell "C"
0.002	588	53
.004	560	51
.006	555	51
.008	455	44
.010	455	44
.016	497	47
.022	438	43
.030	423	42
.040	406	40
.060	362	36
.100	321	32
Centre of Sample	235	17

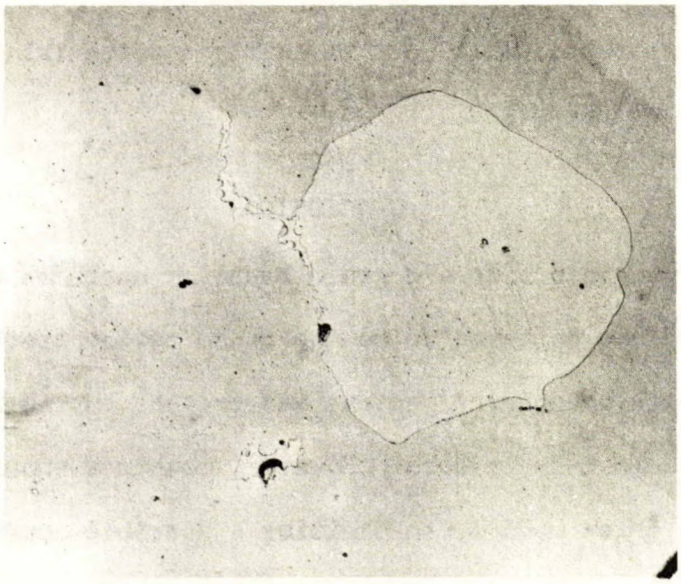
METALLOGRAPHIC EXAMINATION

Examination of samples under a microscope showed the steel to be quite coarse-grained. Several areas were found where quite large patches of carbide at grain boundaries could be easily resolved. Figures 1 and 2 are photomicrographs taken at the surface and closer to the centre of the samples examined.



(Etched in 6% nital; X100)

Figure 1. - Area at surface showing large grain size and patches of carbide concentrated mainly at the grain boundaries.



(Etched in 6% nital; X100)

Figure 2. - Same as Figure 1, except area is near centre of sample.

DISCUSSION

The large grain size and presence of carbides in grain boundaries appear to be the source of the trouble encountered with this casting. It has been shown that the larger the grain size, the greater is the susceptibility to cracking. The presence of the carbides at the grain boundaries increases this tendency to cracking. Consequently, care should be taken to pour the castings with metal as cold as is practicable to ensure a small grain size and to increase either the heat treatment temperature or the soak time at the temperature in use in order to completely dissolve all carbides prior to the water quench.

The phosphorus content found in the casting (0.086%P) is high. It is well known that hot tearing tendencies of manganese steel increase with increasing phosphorus contents, especially when above 0.060%. Although it is not believed to be involved in the present

trouble, high phosphorus is most certainly a potential source of trouble if allowed to go unchecked.

CONCLUSIONS

1. Large grain size and grain boundary carbides were found in the steel, and are believed to be the cause of the trouble.

2. A high phosphorus content was present but is not believed to be involved in this trouble. However, measures should be taken to lower this to below 0.060%, to minimize a possible source of future trouble.

RKB/sws

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