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R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 2013.

Metallurgical Examination of Austenitic Manganese Steel Ball Mill Liner Reported to have given Double Normal Service Life.

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(Copy No. 4 .)

Bureau of Mines
Division of Metallic
Minerals
-
Physical Metallurgy
Research Laboratories

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
Mines and Geology Branch

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Origin of Material and Object of Investigation:

On November 9, 1945, a section from a manganese steel ball mill liner was submitted for metallurgical examination by Joliette Steel Limited, Joliette, Quebec, per R. Rivest, Assistant Sales Manager. The covering letter dated November 7, 1945, stated that the liner had been supplied to Siscoe Gold Mines for a Marcy Ball Mill and had been removed after a service life of approximately twice that of three previous sets of liners. It was requested that an examination be made in order to determine the possible reason for the exceptional life.

PROCEDURE:

1. Chemical Analysis.

The results of the chemical analysis are compared with the A.S.T.M. specifications for austenitic manganese steel.

		As Found	A.S.T.M. Spec.
		- Per Cent -	
Carbon	-	1.28	1.00-1.40
Manganese	-	12.92	10.0-14.0
Silicon	-	0.62	0.25-1.0
Sulphur	-	0.008	0.05 max.
Phosphorus	-	0.044	0.10 "
Chromium	-	1.35	--

2. Mechanical Properties.

The results of a tensile test made on a 0.505-inch diameter test piece are as follows:

Ultimate strength -	- 70,000 p.s.i.
0.2 per cent proof stress	- 60,000
Elongation - -	- 8 per cent
Hardness - -	(214-233 Vickers) (17-19 R.C.)

3. Microscopic Examination.

The photomicrographs in Figures Nos. 1, 2, 3 and 4 are taken from a sample of the ball mill liner steel as received.

Figures 1 and 2 show the normal microstructure of the steel at X100 and X500 magnifications, respectively. The large grain size indicates high pouring temperature, whereas the absence of carbides at the grain boundaries signifies correct heat treatment.

Figures 3 and 4, taken at X100 magnification, indicate the presence of large inclusions and cracks in the steel.

Discussion and Conclusions:

The results of the chemical analysis show that the steel conforms with the A.S.T.M. specifications for austenitic manganese steel, with the exception that chromium has been added. The addition of 1.35 per cent chromium may well be responsible for the increased service life of the liner. The maximum wear characteristics of manganese steel are obtained as a result of work-hardening caused by a pounding action. It is claimed by some authorities that chromium in austenitic manganese steel has the effect of causing the steel to work-harden at lower loads. The presence of chromium in manganese steel subjected to heavy loads may not materially aid in increasing wear resistance. However, it may be possible in this case that the load conditions, plus the chromium content, resulted in work-hardening and increased wear resistance, which may not have occurred if the regular Hadfield steel had been used.

The microscopic examination revealed that the steel had a large grain size (see Figures 1 and 2) resulting from high-pouring temperature. It is common knowledge that the pouring temperature has a marked effect upon the tensile strength of austenitic manganese steel. Hence it may be safe to conclude that the low tensile strength recorded (70,000 p.s.i.) is a direct result of the large grain size and the presence of cracks (see Figure 4). It is also thought that the cracks were induced, probably in the latter part of service life, as a result of the pounding action on a steel already weakened because of the large grain size.

It is not known whether the liner was discarded because of wear, or because of cracking. If the latter were the case, then it is thought that the service life could have been prolonged by more carefully controlling the pouring temperature.

The presence of large inclusions (see Figure 4) does

(Discussion and Conclusions, cont'd) -

not appear to have affected the wearing properties of the steel.

Summarizing:

1. It is suggested that the unusual wear resistance of this liner may be attributed to two conditions:

(a) The presence of chromium in the steel.

(b) Correct heat treatment, the importance of which cannot be over-emphasized.

2. The presence of large inclusions did not appear to have affected the wear resistance.

3. The low tensile strength may be attributed to the cracks which probably formed after a lengthy service life.

4. Assuming that the liner had been discarded because of cracking, it is thought that the service life could have been prolonged to an even greater extent by more careful temperature control in casting.

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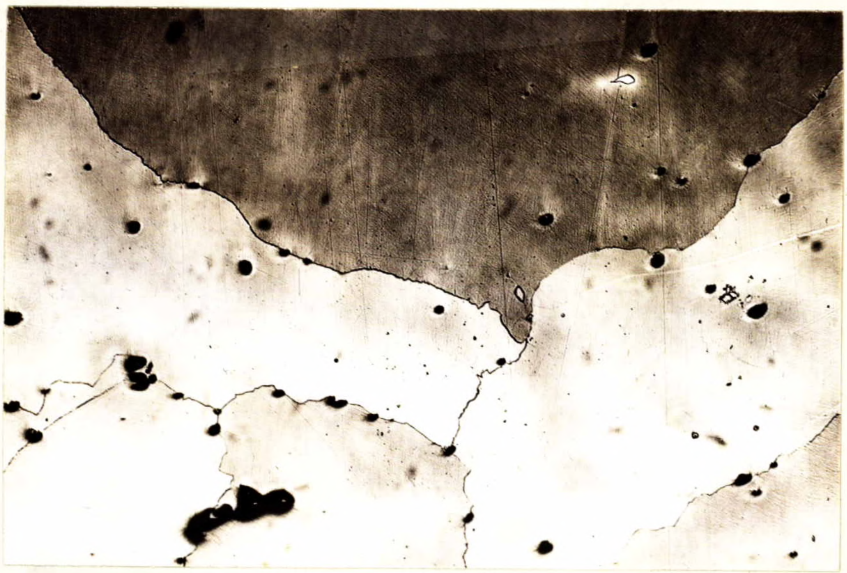
(Figures 1 to 4 follow,)
(on Pages 5 and 6.)

Figure 1.



X100, nital etch.

Note large grain size, indicating high-pouring temperature.

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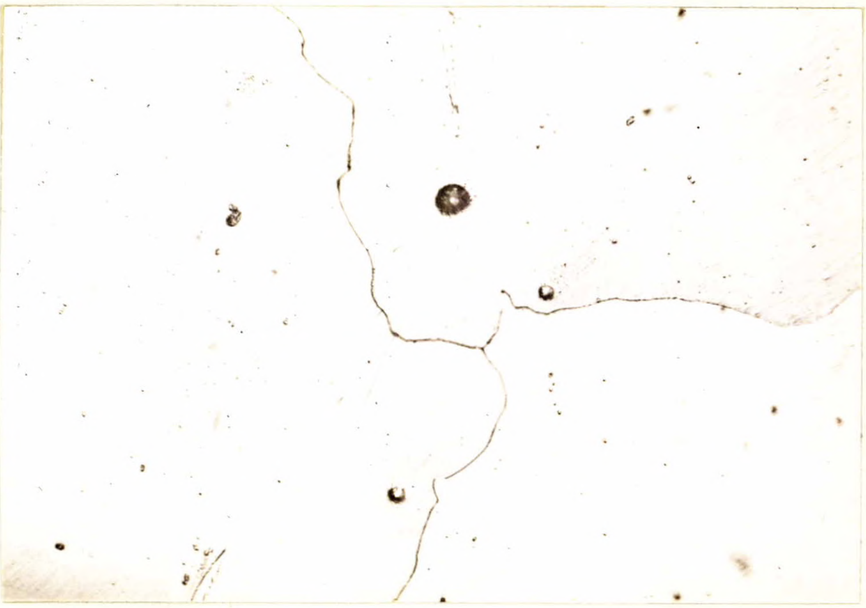
Figure 2.



X500, nital etch.

Note absence of carbides at the grain boundaries, indicating correct heat treatment.

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STEEL AS RECEIVED

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Figure 3.

X100, nital etch.

Showing large inclusions.

Figure 4.

X100, nital etch.

Showing cracks.

STEEL AS RECEIVED.

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