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R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 2034.

Metallurgical Examination of Worn Austenitic
Manganese Steel Casting.

(Copy No. 4.)

Division of Metallic Minerals

Physical Metallurgy Research Laboratories

DEPARTMENT OF MINES AND RESOURCES

Mines and Geology Branch

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Origin of Material and Object of Investigation:

On March 27, 1946, a worn austenitic manganese steel casting (see Figures 1 and 2) was submitted for metallurgical examination by Lynn MacLeod Metallurgy Limited, Thetford Mines, Quebec, per Everett R. Turner, Metallurgist.

The covering letter, dated March 26, 1946, stated that "the casting is subject to hammering and abrasion on the inside curved surface." It was also requested to determine "if the inside face has been work-hardened, or if the hammering has been insufficient to give the maximum hardness."

In a conversation with Mr. E. R. Turner, on

(Origin of Material and Object of Investigation, cont'd) -

April 6, 1946, it was learned that the casting submitted was typical of many which have worn out after a very short service life. It was also learned that the castings were being used for grinding comparatively soft materials.

Figure 1.

WORN MANGANESE STEEL CASTING.
(Approximately 1/3 actual size).

Figure 2.

MANGANESE STEEL CASTING, SHOWING WORN INSIDE SURFACE.

Note also casting defects.

Procedure:

(1) Visual Examination:

Visual examination of the worn inside surface revealed some casting defects in addition to the evidence of wear.

(Procedure, cont'd) -

(2) Chemical Analysis:

The results of the chemical examination are compared in the following table with A.S.T.M. specifications for austenitic manganese steel:

		As Found	A.S.T.M. Specifications
		- Per	Cent -
Carbon	-	1.51	1.00-1.40
Manganese	-	13.46	10.0-14.0
Silicon	-	0.94	0.25-1.0
Sulphur	-	0.005	0.05 max.
Phosphorus	-	0.019	0.10 max.
Chromium	-	0.40	
Nickel	-	Nil.	
Molybdenum	-	Trace.	

(3) Hardness Test:

Hardness readings were made with a Tukon microhardness tester, using a 500-gram load, on a sample cut from the wearing surface, in order to determine the extent and depth of the work hardness. The results are given in the following table:

Distance from Wear Surface, inches		HARDNESS NUMBER Knoop	Rockwell "C" (Converted)
Nil	-	490	47
0.005	-	361	32
0.01	-	303	25
0.015	-	246	17
0.02	-	246	17

(4) Microscopic Examination:

Figures 3 and 4, taken at X100 and X500 magnifications respectively, show considerable quantities of excess carbides throughout the steel.

Figure 5, taken at X100 magnification, illustrates a crack extending inward from the wearing surface, This crack is typical of a great number found in the metal. Note, also, evidence of work hardness at the wearing surface.

(Continued on next page)

(Procedure, cont'd) -

Figure 6, taken at X500 magnification, also shows evidence of work hardness at the wearing surface.

Figure 7 (X100 magnification) illustrates shrinkage porosity in the casting.

Figure 8, taken at X200 magnification, illustrates the extent of the work hardness. Impressions were made with a Tukon hardness tester, using a 500-gram load.

Discussion and Conclusions:

The results of the chemical analysis indicate that the carbon content of the casting is considerably above the allowable maximum. The resulting carbides, which have a very great embrittling effect upon the metal, are clearly shown in Figures 3 and 4. The wear resistance would also be greatly reduced because of the intercrystalline cracking (see Figures 5 and 6). Microscopic examination revealed a large number of cracks, similar to that shown in Figure 5, extending inward from the wearing surface.

The results of the hardness test and microscopic examination prove conclusively that some work hardening has taken place. However, the fact that the hardened surface extends to a distance of only 0.015 inch proves that the impact loads are not very great. It should be noted that the hardened layer is so shallow that the Vickers hardness tester failed to disclose the presence of work hardness.

It is common knowledge that the beneficial wear resistance of austenitic manganese steel can only be realized under service conditions in which the impact loads are sufficiently great to result in an appreciable work hardness. Since the work-hardened surface was found to have extended to a distance of 0.01 to 0.015 inch, it may be safely concluded that the impact loads were quite light and were insufficient to

(Discussion and Conclusions, cont'd) -

produce the work hardness required to derive the maximum benefit from the steel. Under these circumstances, it is not surprising that the wear resistance was found to be very low. This condition was also aggravated by the excessive carbon content.

Summary of Conclusions:

1. The carbon content was found to be considerably above the permissible maximum, resulting in the presence of carbides which have a marked embrittling effect upon the steel.

2. Many cracks were found, extending inward from the wearing surface.

3. The work-hardened surface was quite shallow, indicating low impact loads.

4. The low impact loads, plus the embrittling effect of the carbides, combined to produce poor wear resistance.

Recommendations:

1. The carbon content should be kept below the maximum of 1.40 per cent.

2. It is suggested that consideration be given to the substitution of a different type of steel, one with greater hardness.

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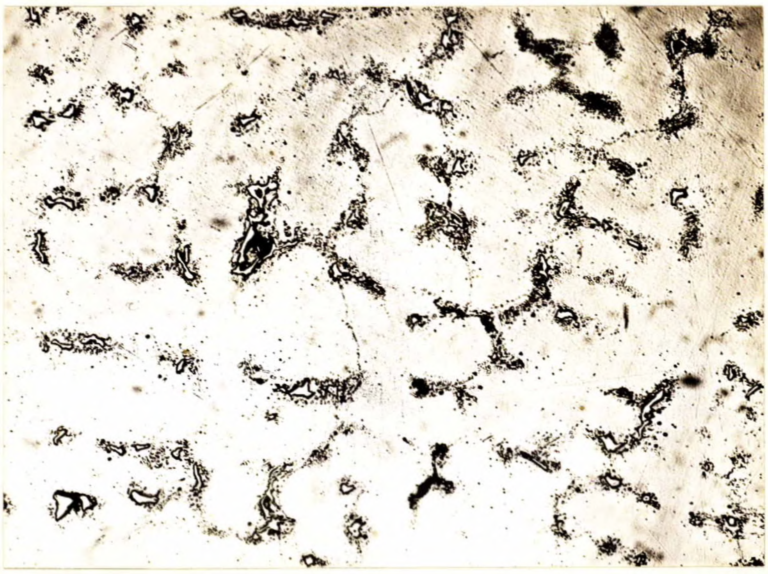
(Figures 3 to 8 follow,)
(on Pages 6 to 8.)

Figure 3.



X100, nital etch.

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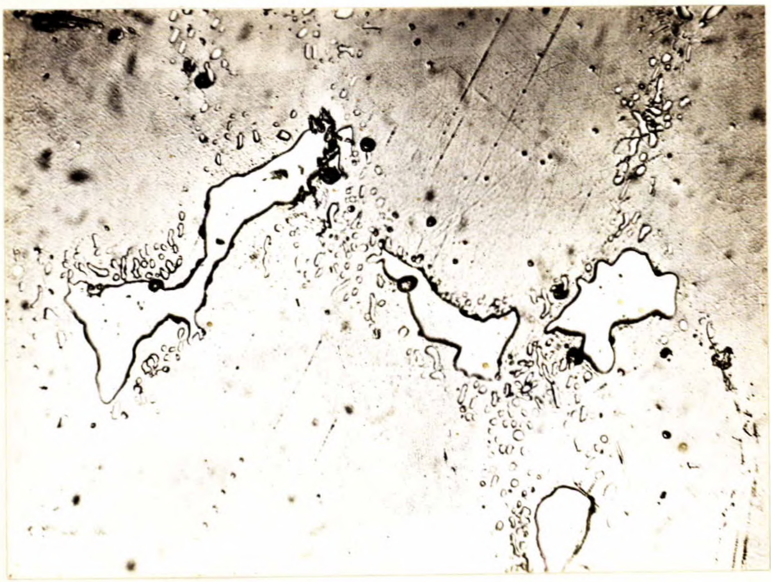
Figure 4.



X500, nital etch.

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Note excess carbides in
Figures 4 and 5.

Figure 5.

X100, nital etch.

Note crack at wearing surface, characteristic of many found in the metal. Note, also, indications of work hardening.

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Figure 6.

X500.

TAKEN NEAR WEARING SURFACE.

Note intercrystalline crack and signs of work hardening.

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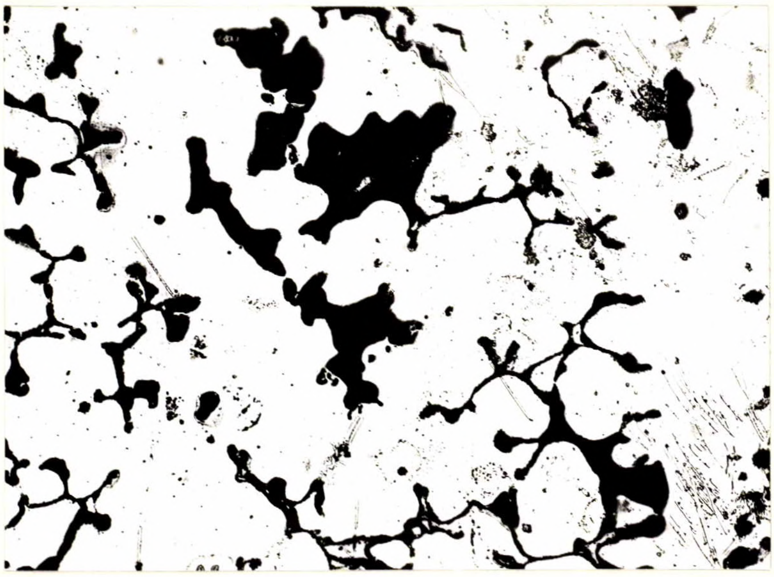
Figure 7.



X100, unetched.

SHOWING SHRINKAGE DEFECTS.

(Taken near wearing surface.)

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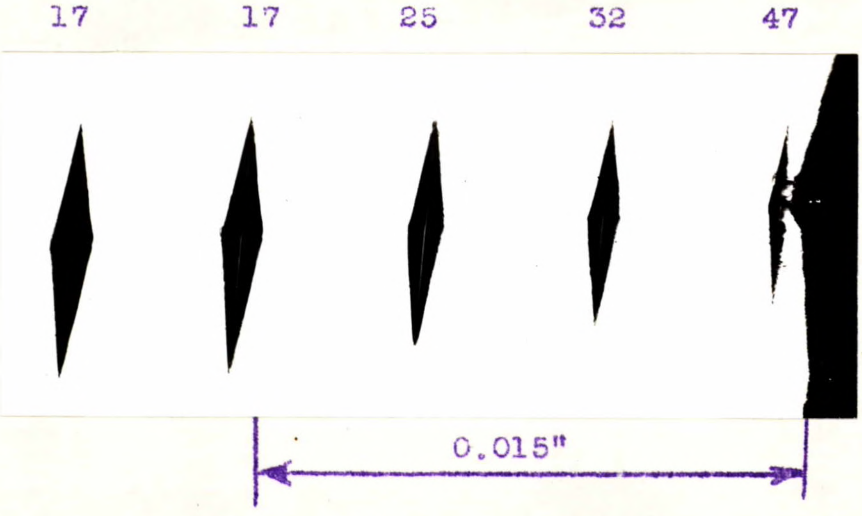
Figure 8.

ROCKWELL "C"



X200.

HARDNESS READINGS MADE WITH A TUKON HARDNESS TESTER, SHOWING MAGNITUDE AND DEPTH OF SURFACE WORK HARDNESS.

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