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O T T A W A October 19th, 1942.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1316.

An Examination of Three Malleable Cast Iron Test Bars, ex Sawyer-Massey, Hamilton.

(Copy No. 4.)

BUREAU OF MINES
DIVISION OF METALLIC MINERALS
ORE DRESSING AND
METALLURGICAL LABORATORIES

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
MINES AND GEOLOGY BRANCH

O T T A W A October 19th, 1942.

R E P O R T

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ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. I.516.

An Examination of Three Malleable Cast Iron Test Bars, ex Sawyer-Massey, Hamilton.

Source of Material and Object of Investigation:

On October 9th, 1942, three test specimens of malleable cast iron (ex Sawyer-Massey, Hamilton) were received from the British Admiralty Technical Mission, 58 Lyon Street, Ottawa, Ontario, for examination. These three test pieces were described as follows:

(Continued on next page)

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

Sample (1): As cast test bar and annealed with gun cradle.

Sample (2): As above, but already broken. Results reputed to be 63,000 to 69,000 p.s.i. ultimate; elongation, 7 per cent to 8 per cent.

Sample (3): As above, but machined from a special thick block cast on the main casting and annealed therewith. Annealing does not appear to have penetrated. Specimen reported to have broken at 25,000 p.s.i., with no elongation.

In the accompanying letter, File No. 11-11-8-6, dated October 8th, 1942, signed by Lieut. Commander (E) G. Taylor, R.N.V.R., the following information was requested:

Sample	Information Requested
No. 1.	That ultimate, yield, elongation, and impact be checked.
No. 2.	That impact values be obtained and the other figures be estimated.

An opinion was requested regarding the degree of malleability which the above samples had received.

No. 3.	That impact value be obtained and other physical properties be estimated therefrom.

An earlier report submitted, P.M. Lab. Report No. 5127, related to cast malleable iron brake pedals.

Physical Tests:

There was a shift in the mould in which Sample No. 1 was cast. This is shown in Figure 1. This condition is not conducive to good test bars. The results are likely to be erratic since it is very difficult to determine the correct cross-sectional area.

Square izod impact bars, 0.394 in. square, and having a standard "V" notch, were prepared from the broken portions of all three samples. Physical test results are recorded in Table I.

(Continued on next page)

(Physical Tests, cont'd) -

Table I. - Physical Test Results.

Sample	Ult. tensile strength, p.s.i.	Elongation, % in 2 in.	Izod impact, ft.lb.
No. 1.	36,600	5	10
No. 2.	-	-	7
No. 3.	-	-	3

Figure 1.
View of fractured section of test bar, Sample No. 1, showing offset in mould.

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Chemical Analysis:

A complete chemical analysis was obtained from each sample. The results are recorded below:

	Sample No. 1.	Sample No. 2.	Sample No. 3.
	- Per cent -		
Silicon -	1.12	1.14	1.15
Manganese -	0.33	0.32	0.33
Sulphur -	0.08	0.079	0.069
Phosphorus -	0.12	0.15	0.16
Chromium -	Not detected.	Not detected.	Not detected.
Nickel -	0.16	0.26	0.30
Molybdenum -	Not detected.	Not detected.	Not detected.

Since it is not possible to obtain reliable total carbon analyses from malleable iron after annealing, no analysis was made for this element.

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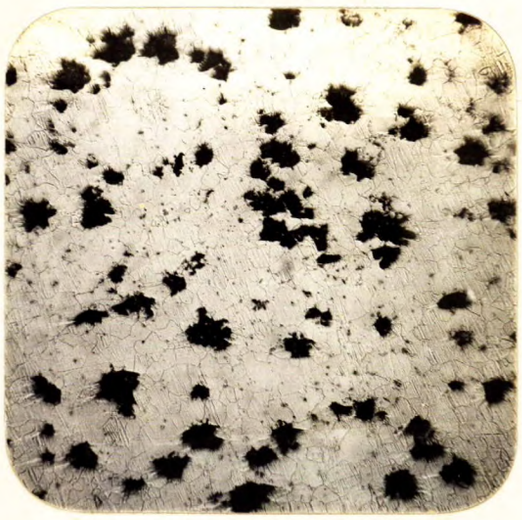
Microscopic Examination:

Photomicrographs at a magnification of 50 diameters were obtained of the structure of the metal in the three samples submitted. The etchant used was 4 per cent alcoholic solution of picric acid. These photomicrographs are reproduced in Figures 2 to 7 inclusive.

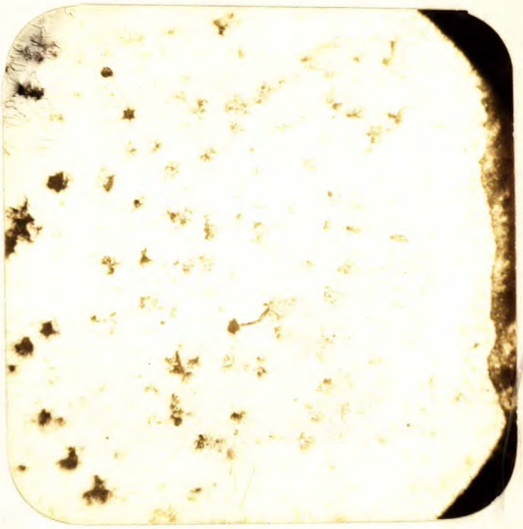
(Continued on next page)

Figure 2.



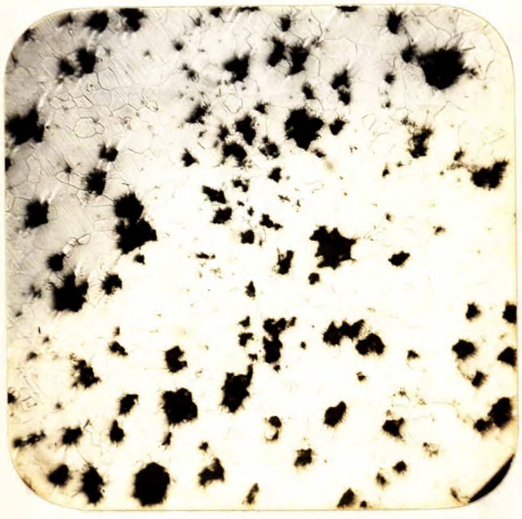
AT CENTRE OF SAMPLE NO. 1.

Figure 3.



AT EDGE OF SAMPLE NO. 1.

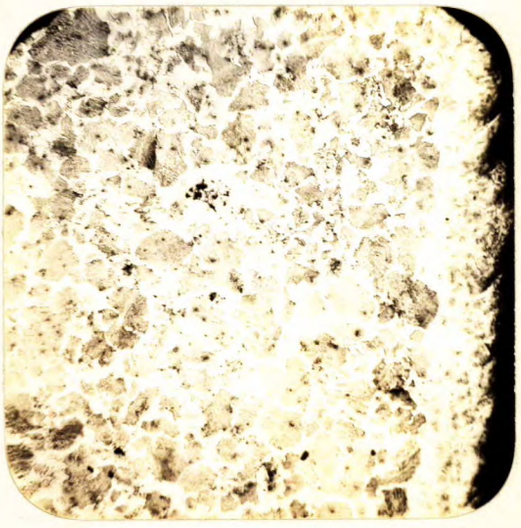
Figure 4.



AT CENTRE OF SAMPLE NO. 2.

Compare with Figure 2.

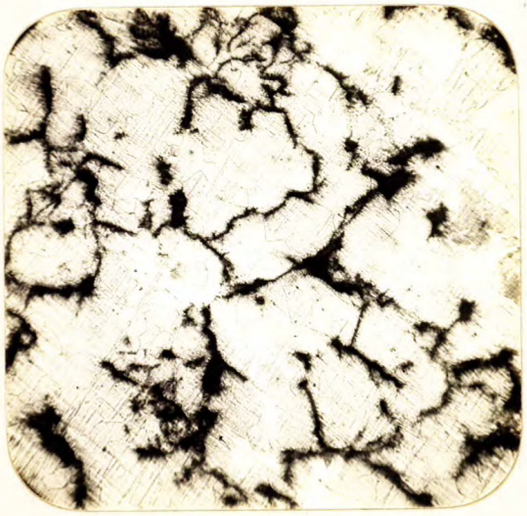
Figure 5.



AT EDGE OF SAMPLE NO. 2.

Compare with Figure 3.

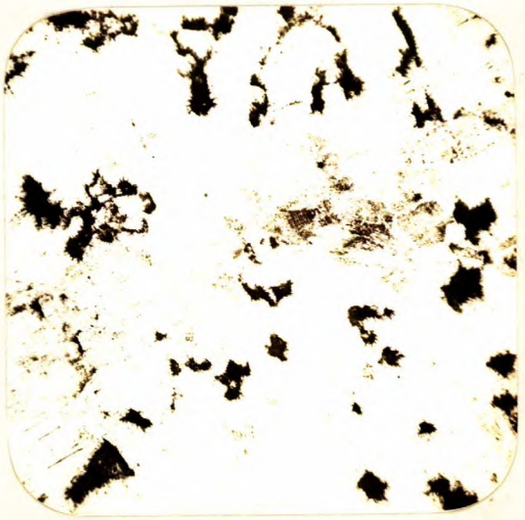
Figure 6.



SAMPLE NO. 3.

Note primary graphite.

Figure 7.



SAMPLE NO. 3.

Note presence of pearlite.

THE ABOVE ARE ALL PHOTOMICROGRAPHS, X50, PICRAL ETCH.

Discussion of Results:

It will be noted that the physical properties obtained on Sample No. 1 are well below those desired, i.e., 50,000 p.s.i. ultimate and 15 per cent elongation. From the photomicrographs, Figures 2 and 3, it is evident that the metal has been fully annealed but that the size and dispersion of the temper carbon are poor. The same type of structure is noted in the centre of Sample No. 2 (Figure 4), but the edge of this sample is pearlitic (see Figure 5). This pearlitic case is about a sixteenth of an inch thick. It is characteristic of faulty annealing practice and can be obtained if the cooling rate is too rapid through the critical range. Such a structure will give high tensile strength but poor elongation.

The poor temper carbon structure can result from the improper annealing cycle for the chemical analysis of the material. Since nickel is a graphitizing agent it would shorten the soaking time required.

For casting sections have a freezing rate of the same order as that of the test bars, the analysis of the iron should result in good malleable iron when correctly annealed. There was no primary graphite visible in Samples Nos. 1 and 2.

It will be noted from Figure 6 that there is a great deal of primary graphite present in Sample No. 3. This could be caused by the high silicon (1.15 per cent) combined with the 0.3 per cent of nickel present. Both of these elements are graphitizing agents and would encourage the precipitation of primary graphite on freezing.

Therefore, while the analysis used could be made into good malleable iron in sections equivalent to the "as cast" test bars by correct annealing practice, it is not suitable for heavier sections as represented by Sample No. 3.

It would therefore be necessary to adjust the analysis

(Discussion of Results, cont'd) -

to suit the heavy section and then to adjust the annealing cycle to give good structure and properties in the light section. It might be found necessary, if the nickel cannot be eliminated, to lower the silicon to 0.8 per cent. If the nickel can be eliminated 0.9 to 1.0 per cent silicon might be found correct.

Complete annealing may not be possible in the heavy section without overannealing the light section. However, this will have to be determined by practice.

Conclusions:

1. Sample No. 1 has been completely malleabilized, but, due to too long an annealing cycle for the silicon and nickel present, the resulting structure does not have good physical properties.

2. Sample No. 2 received a faulty annealing treatment, which produced high tensile strength but low elongation. Properly annealed, the properties of Samples Nos. 1 and 2 would be of the same order. Too long an annealing period for the silicon and nickel present was chosen; also, this bar was cooled too quickly.

3. Due to nickel and high silicon, primary graphite formed on freezing in the section represented by Sample No. 3. A metal of this structure would be expected to have very low physical properties. The presence of pearlite (Figure 7) is due to too rapid a cooling rate.

Recommendations:

1. More care should be taken in making the moulds for the tensile test bars. The bar submitted as Sample No. 1 was very unsatisfactory.

2. If the nickel cannot be eliminated, the silicon should be lowered; even if the nickel can be eliminated, an improvement in physical properties should be obtained by a somewhat lower silicon content.

3. Details of annealing practice, such as correct calibration of thermocouples, proper annealing time to suit the chemical analysis of the metal, uniform temperature distribution in the annealing furnace, and uniform cooling rate, should be checked.

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