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OTTAWA November 30th, 1932.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1328.

Examination of Pearlitic Malleable Iron from the Smiths Falls Malleable Castings Co., Smiths Falls, Ontario.

(Copy No. 10.)

BUREAU OF MINES
DIVISION OF METALLIC MINERALS

ORE DRESSING AND
METALLURGICAL LABORATORIES

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
MINES AND GEOLOGY BRANCH

OTTAWA November 30th, 1942.

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Origin of Request:

On October 28th, 1942, Mr. M. W. Hollands, of the Materials Inspection division of the Inspection Board of the United Kingdom and Canada, Ottawa, Ontario, requested that an investigative visit be made by one of our metallurgists to the plant of the Smiths Falls Malleable Castings Company, Smiths Falls, Ontario, in order to determine the cause of lowered ductility in some malleable iron test pieces.

Nature of Problem:

On November 2nd, 1942, a visit was made to the Smiths Falls Malleable Castings Company, at Smiths Falls, Ontario.

It was evident that a standard quality of malleable iron was being produced. From the fracture of the product, however, it was obvious that the annealing operation was incomplete. The pearlite rim in the test bars was the cause of lowered ductility.

Fractures:

Figure 1.

Figure 2.

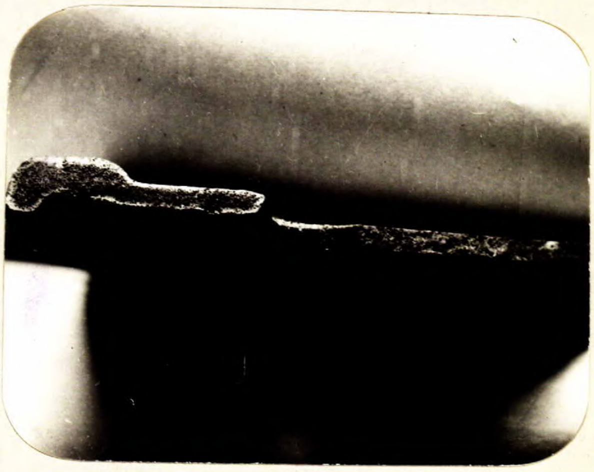


Figure 3.

Figure 4.

Figure 1 shows the regular black fracture which is typical of good malleable iron. This was characteristic of

(Fractures, cont'd) -

the Smiths Falls company's product before the nickel and chromium occurred in the pig iron. Figures 2, 3 and 4 show the "white rim," or frosty crystalline appearance, indicating incomplete annealing.

Chemical Analysis:

Complete analysis of a heat cast at this time was as follows:

		Per cent
Carbon	-	2.48
Silicon	-	1.00
Sulphur	-	0.068
Phosphorus	-	0.108
Nickel	-	0.19
Chromium	-	0.04

Recommended Change in the Process:

From the presence of nickel and chromium, and the appearance of the fractures, it was evident that a longer annealing cycle would be necessary. It was recommended, therefore, that the cooling time be increased from 24 to 48 hours.

Specimens of a heat of malleable so treated were tested, with the following results:

		S P E C I M E N S*		
		A	B	C
Tensile strength, p.s.i.	-	65,700	65,500	61,200
Yield point, p.s.i.	-	-	37,000	35,300
Elongation, in 2 inches, per cent	-	-	13	12.5
Bend test	-	39°	103°	54°

* A was marked 10-27-42-4.
B " " 10-26-42-4.
C " " 10-24-42-T.

The specifications used by Canadian and American manufacturers in purchasing malleable iron are as follows:

(Continued on next page)

(Recommended Change in the Process, cont'd) -

	ASTM A-47 Grade 35018	ASTM A-47 Grade 32510	ASTM A-197 Cupola malleable
Tensile strength, p.s.i., minimum -	53,000	50,000	40,000
Yield point, p.s.i., minimum -	35,000	32,500	30,000
Elongation, in 2 inches, per cent, minimum	18	10	5

The metal submitted by the Smiths Falls company was well above the requirements for ASTM Grade 32510, and therefore is a standard grade of malleable iron.

PEARLITIC MALLEABLE IRON:

Pearlitic malleable iron has been developed to replace steel castings, and for many machine parts it is considered superior in wearing properties. The difference between regular and pearlitic malleable is that in pearlitic malleable elongation is reduced and tensile strength is increased. This is exactly what has happened to the Smiths Falls product. For many mechanisms strength is considered to be more important than ductility. Recent articles in the AMERICAN FOUNDRYMAN, on Arma steel, show to what uses pearlitic malleable is being put.

Properties of pearlitic malleable of different types, as given by Carl Joseph[1], are:

Tensile strength, p. s. i.	Yield strength, p. s. i.	Elongation, in 2 inches, per cent
57,500	43,000	8
75,000	56,000	6
88,000	71,000	4
104,000	90,000	2

The above material would not pass a 90-degree bend

[1] AMERICAN FOUNDRYMAN, Nov. 1942.

(Pearlitic Malleable Iron, cont'd) -

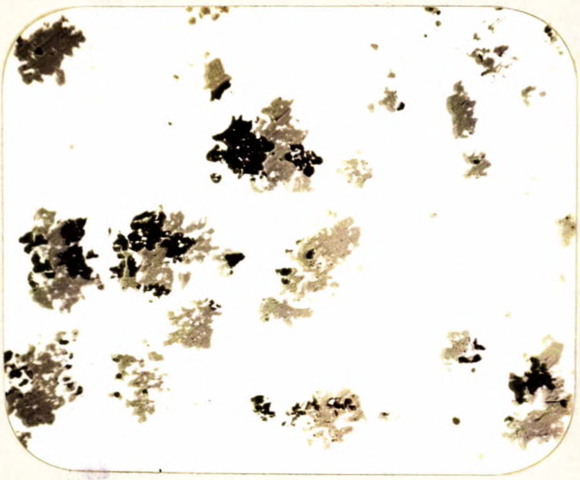
test, and yet it is used for gears, connecting rods, cam shafts, pistons, and many other highly stressed parts. The bend test, therefore, is not a very satisfactory measure of metal quality.

Bend Test:

The bend test was developed in England to determine whether whiteheart malleable had been sufficiently decarburized. Its use to evaluate blackheart malleable is not recommended. High strength metal will not bend as far as low strength metal; hence the bend test gives a false impression of metal quality. The use of decarburizing packing in the annealing pots will increase the bend angle at the expense of a considerable loss in tensile strength. 10 per cent iron ore in the packing material has been used.

Microstructure:

Figure 5.



X100, nital etch.

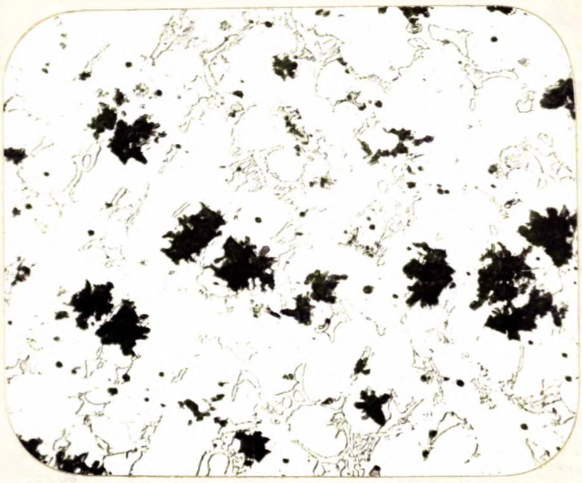
STANDARD MALLEABLE.

Figure 5 shows the product of the Smiths Falls Malleable Castings Co. before difficulty was encountered with

(Microstructure, cont'd) -

nickel and chromium. This is a high-grade product, which would probably conform to ASTM A-47, Grade 35018.

Figure 6.



X100, nital etch.

SOAKING TIME TOO SHORT IN ANNEAL.

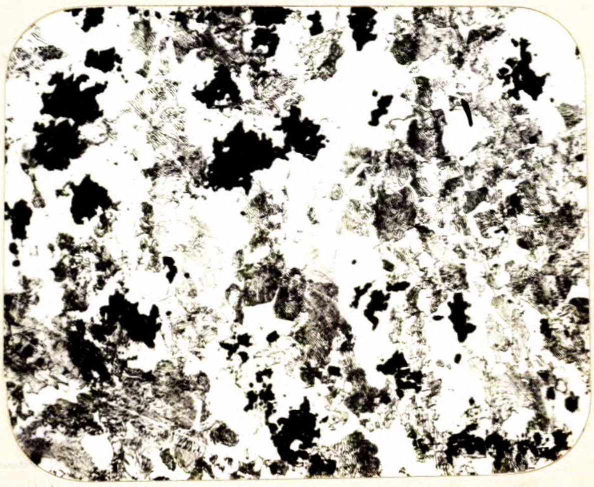
Figure 6 shows large carbides remaining after annealing. These can be eliminated by --

(1) A higher soaking temperature,
and/or

(2) A longer time at soaking temperature,

during the annealing process.

Figure 7.



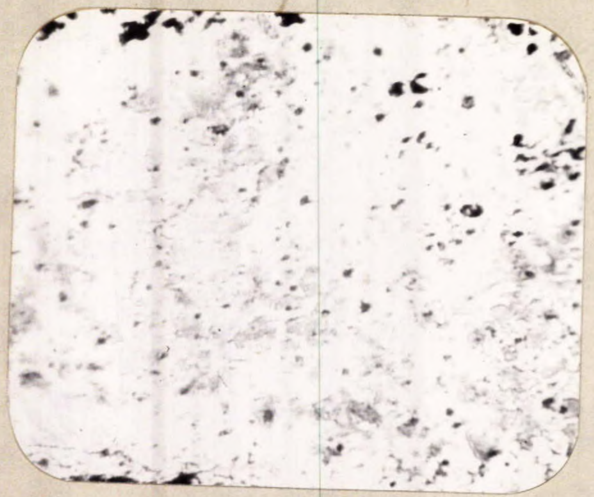
X100, nital etch.

COOLING TOO FAST DURING ANNEAL.

(Microstructure, cont'd) -

Pearlite areas in Figure 7 show the need for slower cooling from 1450° to 1200° F.

Figure 8.



X100, nital etch.
24 HOURS' COOLING.

Figure 9.

X100, nital etch.
48 HOURS' COOLING.

Figure 8 and 9 show the effect of increased cooling time on the microstructure.

Figure 10.

X100, nital etch,
PRIMARY GRAPHITE AFTER ANNEALING.

Figure 10 shows the graphite flake formation

(Microstructure, cont'd) -

resulting from black spots in the 'as cast' structure. It is obvious that this weakens the metal.

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Figure 11.

PRIMARY GRAPHITE IN TEST SPRUE.

(Actual size).

The black spots in the specimen of Figure 11 give rise on annealing to a spongy network of graphite flakes which has neither strength nor ductility.

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DISCUSSION OF PROBLEM:

If it is desired to avoid making pearlitic malleable, several remedies are available:

1. Increasing carbon will give a more fluid metal, tend to produce primary graphite, and reduce the condition shown in Figures 2 and 3.

2. Increasing silicon will tend to produce primary graphite and reduce the condition of Figures 2 and 3.

(Continued on next page)

(Discussion of Problem, cont'd) -

3. Addition of steel in furnace charge will tend to reduce primary graphite.

4. Increased soaking time will eliminate the condition in Figure 2.

5. Increased soaking temperature will eliminate the condition in Figure 2.

6. Increased cooling time will eliminate most of the white crystalline fractures and the pearlitic condition shown in Figure 3.

ONE CHANGE AT A TIME is an excellent rule to follow when a foundry process is being altered. At the present time (November, 1942) the cooling period has been lengthened from 24 to 48 hours. After this change has been in operation for a few weeks, its effect can be known. Then consideration can be given to the question of whether any further change is necessary.

Control of Annealing Temperatures -

It is recommended that a recording type of instrument be used to keep a record of annealing conditions. Otherwise, annealing practice may vary from lot to lot and the cause of poor fractures may not be discovered.

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