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O T T A W A March 23rd, 1943.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1375.

Examination of a Failed Bend Test
Specimen of Mild Steel.

(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

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Source of Material and Object of Examination:

On March 6th, 1943, Mr. A. A. Paoli, Sales Manager, Vulcan Iron Works Limited, Winnipeg, Manitoba, submitted for examination a specimen of cast mild steel which had failed to pass the bend test. It was stated that the specification required that the steel be bent through 90 degrees on a 1-inch radius without sign of fracture. A metallurgical examination was requested in order to determine why the steel failed.

Chemical Analysis:

Drillings were taken from the test specimen and then analysed in order to check the results supplied on this heat. Both analyses are given below:

	Analysis Figures on Bar TB2703	
	Supplied by Vulcan	Obtained by Bureau of Mines
	- Per cent -	
Carbon	0.22	0.26
Silicon	0.27	0.36
Manganese	0.66	0.70
Sulphur	0.042	0.048
Phosphorus	0.043	0.041
Chromium	-	None detected.
Nickel	-	" "
Vanadium	-	" "

Physical Tests:

Supplied by Vulcan:

Ultimate strength, p.s.i.	-	68,400
Yield strength, p.s.i.	-	42,100
Elongation, per cent in 2 inches	-	33.0
Reduction in area, per cent	-	42.0
Fracture	-	⅓ cup

Obtained by Bureau of Mines:

Izod impact tests -		Ft.lb.	Fracture
Notch No. 1	-	19	(Coarse and
Notch No. 2	-	21	(crystalline.

Macroscopic Examination:

The steel was observed to have a coarse dendritic fracture and also to contain several small particles of sand embedded in the steel. The coarse nature of the fracture is illustrated in Figure 1. Figure 2 shows the large shrinkage cavities encountered in the test specimen, approximately half an inch below the fracture.

(Continued on next page)

(Macroscopic Examination, cont'd) -

Figure 1.

PHOTO SHOWING DENDRITES IN STEEL.

(Approximately 4 times actual size).

Figure 2.

PHOTO SHOWING SHRINKAGE CAVITIES.

(Approximately 7/8 actual size).

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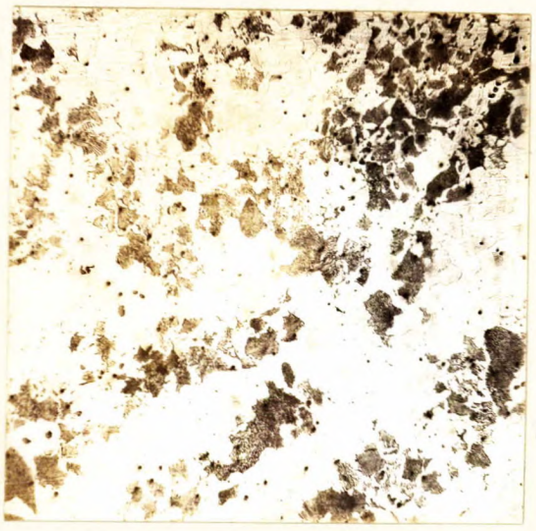
Heat Treatment:

A section of the steel bar was normalized at 1650° F. and then drawn at 1200° F., in order to see what improvement, if any, could be obtained in the distribution of the carbides in the steel.

Microscopic Examination:

A section of the steel bar was given a metallographic polish and examined under the microscope in the unetched condition. The steel was found to be fairly clean. However, several areas of shrinkage cavities were noted. The steel was etched in a solution of 5 per cent picric acid in alcohol and re-examined. Figures 3 and 4 are photomicrographs, at X100 and X1000 magnifications respectively, showing the structure of the steel in the 'as received' condition. Figure 5 is a photomicrograph, at X100, showing the structure of the steel after receiving a normalizing heat treatment. In Figures 3, 4 and 5, the structure consists of pearlite (the dark etching material) and ferrite (the light constituent).

Figure 3.



X100, etched in 5 per cent picral.

Figure 4.

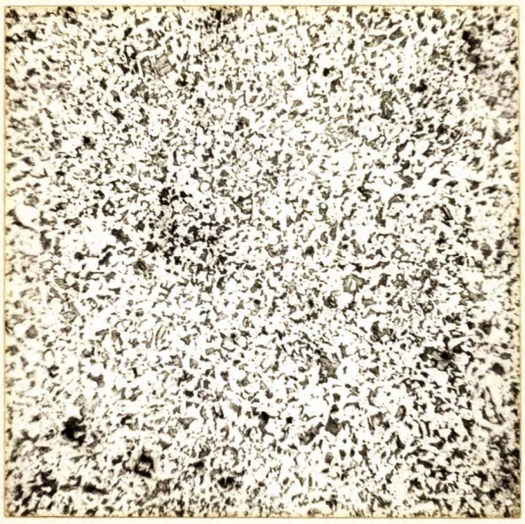
X1000, etched in 5 per cent picral.

STRUCTURE OF STEEL IN THE ANNEALED CONDITION.

(Continued on next page)

(Microscopic Examination, cont'd) -

Figure 5.



X100, etched in
5 per cent picral.

NORMALIZED AND DRAWN.

-

Discussion of Results:

The results of chemical analysis did not check with those supplied for this heat of steel. The composition, however, would appear to be normal for steel made by the acid electric steel process. The absence of any large number of non-metallic inclusions in the steel would indicate that the steel had been properly made. The presence of dendrites in the steel shows that the cast structure was not broken up during the heat treatment. An improved distribution of the carbides in the steel can be obtained by a normalizing-and-draw heat treatment. (Compare Figures 3 and 5).

The presence of shrinkage cavities in the steel is due to poor feeding of the casting during the solidification period. The presence, in the steel, of small particles of sand may have contributed to the development of shrinkage cavities in this test specimen by chilling the metal and

(Discussion of Results, cont'd) -

therefore preventing the proper feeding of the casting. There was, also, evidence of blowholes adjacent to the shrinkage cavities. This may also have resulted from the presence of the sand.

Apart from the poor bend properties, the other physical properties of the steel appeared to be satisfactory.

CONCLUSION:

It is concluded, from the examination of this bend test specimen, that failure was due to the presence of shrinkage cavities in the steel.

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NBB:GHB.