OTTAWA September 2nd, 1943.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1490.

Examination of Two Broken Universal Carrier Track Links.

(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

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Origin of Material and Object of Investigation:

The two broken links were blackheart malleable iron track links that had been produced by the International Harvester Company of Canada Limited, Hamilton, Ontario, and austempered at these Laboratories. They had been forwarded to the Ford Motor Company of Canada Limited and used in Tank Field Test No. 5 which is being conducted at Windsor at the present time. The links failed in field test at 1,026 miles.

They were then submitted to these Laboratories by Dr. C. W. Drury, Director of Metallurgy, Army Engineering Design Branch, Department of Munitions and Supply, Toronto, Ontario, under the following requisition order, dated August 18th, 1943:

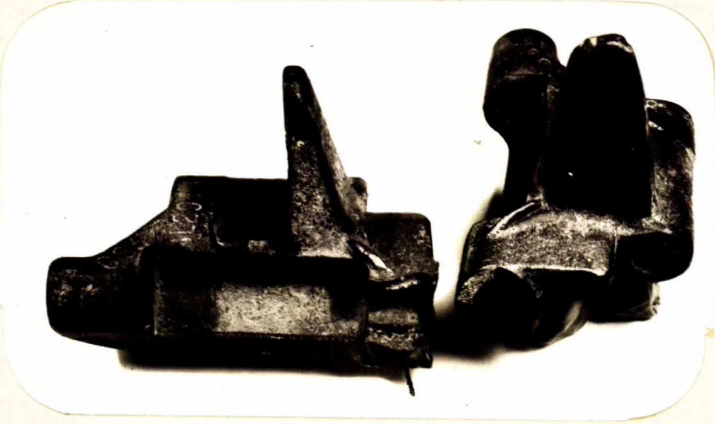
> Requisition No. 496, A.E.D.B. Lot No. 362,
> Report No. 34, Section G, Test No. 2.

It was requested that these links be investigated to determine cause of failure.

Nature of Fracture:

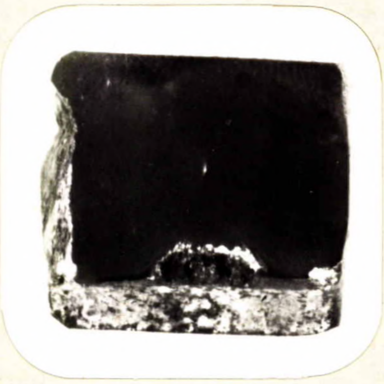
Both links failed across the eye-hole and barrel on the three-eye side. Figure 1 shows the nature of this fracture. Observe the shrink at the fracture of Link No. 1. Figure 2 illustrates a section cut through the shrinkage area.

Figure 1.



NATURE OF FRACTURE.
(Arrow indicates shrink).

Figure 2.



SHRINKAGE AREA.
(Twice actual size).

Hardness Survey:

Sections were cut transversely through the barrel of each link, as close as possible to the point of failure. Hardness surveys were made across the grouser to the eye-hole, using the Vickers hardness testing machine with loads as indicated.

LINK NO. 1.

Load, kilograms	V.P.N.	Distance from eye-hole, in inches
10	274	0.30
10	285	0.20
10	285	0.10
10	219	0.09
10	222	0.06
10	242	0.04
10	144	0.03
10	176	0.01
1	467	Surface.

LINK NO. 2.

Load, kilograms	V.P.N.	Distance from eye-hole, in inches
10	207	0.87
10	207	0.22
10	172	0.10
10	180	0.06
10	210	0.04
10	218	0.02
10	218	0.01
1	(339-390)	Surface.

Impact Test:

A lug of each link was subjected to the standard drop impact test. This test consists of dropping a 50-pound weight on the specimen from various heights. (An illustration and further description of the impact machine may be found in O.D.M.L. Report of Investigation No. 1463, August 2nd, 1943).

The results of this test are as follows:

Link No.	Blows	Ft.-lb.	Remarks
1	1	300	Failed.
2	1	300	Failed.

Hammer Test:

A link is considered to have sufficient ductility and toughness when the eye-holes will withstand the blows of a hammer until they are two-thirds of their original diameter. Both links passed this test.

Microscopic Examination:

The links were sectioned at the point of fracture and a metallographic examination was made across each section. In addition to the areas of shrink revealed by the macroscopic examination, the microscopic study showed that both links had typical structures at the surface of the eye-hole, i.e., an outer cyanided layer backed by an area of ferrite of approximately 0.01 inch thickness.

The structure of the remainder of the eye-hole consisted, in the case of Link No. 1, of temper carbon and pearlite (in which were dispersed small particles of ferrite and cementite) and, in the case of Link No. 2, of temper carbon in a background of approximately equal parts of ferrite and pearlite. These structures are shown respectively in Figures 3 and 4.

The metal in the barrel of Link No. 1 was found to consist of temper carbon in a background of pearlite containing small particles of cementite. Link No. 2 barrel metal had the same structure but apparently contained no cementite.

Figure 3.

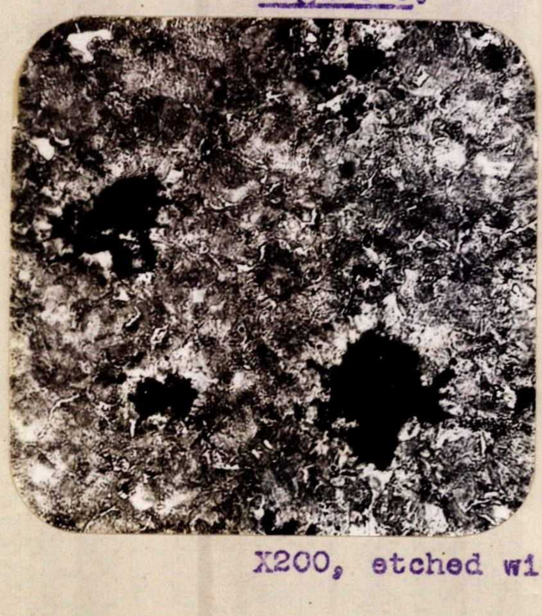


Figure 4.

X200, etched with 2 per cent nital.

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Discussion:

Undoubtedly the shrink in the eye-hole of Link No. 1 was at least a contributory cause of failure.

The purpose of austempering these links was to obtain a higher hardness without any sacrifice in ductility. The specification covering the manufacture of malleable iron Universal Carrier track links required that the hardness of the eye-hole section should not exceed 200 V.P.N., although a 350 V.P.N. hardness was allowed in the barrel of the link. This low V.P.N. hardness (200) was found necessary since malleable iron links heat-treated in the usual way were found to be brittle if the eye-hole hardness exceeded this figure.

Experimental work in these Laboratories (O.D.M.L. Investigation No. 1075, September 25th, 1941), however, indicated that the eye-hole hardness could be raised to around 30 Rockwell 'C' while still maintaining satisfactory ductility (as measured by the hammer test).

It was argued that the increase in hardness should not only lower the amount of the eye-hole stretch but also increase the wear resistance of the link. Indeed, it was hoped that the abrasive resistance might exceed that of the steel casting.

The results of hammer tests indicate that both links have satisfactory ductility. The hardness of the eye-hole area of Link No. 1 might have been increased with some improvement of the physical properties of the link, but it is not considered to be unduly low. The eye-hole core hardness of Link No. 2 is definitely too low. This link would not have better physical properties than would a link given the conventional heat treatment.

Both links failed to withstand a 300-ft.-lb. blow in

(Discussion, cont'd) -

the drop impact test. This does not compare very favourably with the impact properties of a cast steel link, which in some cases will withstand 3 blows of 400 ft.-lb. at the same part of the casting. However, it must be remembered that the specifications used in the manufacture of blackheart malleable links require only that they resist an impact of 112 ft.-lb.

The microscopic examination shows that the low hardness value of Link No. 2's eye-hole metal is not due to faulty austempering treatment but rather to excess decarburization. Apart from the effect of the ferrite areas on the hardness, the lower carbon material is subject to the additional disadvantage that it is very difficult to austemper.

The presence of cementite areas in Link No. 1, although not considered a serious defect, indicates that the link cooled too rapidly in the annealing operation.

CONCLUSIONS:

1. A contributory cause of failure of one of the links was the presence of a shrinkage area in the eye-hole.

2. The other broken link did not have the properties required in the austempered product. Also, excess decarburization in the eye-hole area further decreased the strength.

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