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OTTAWA October 2nd, 1943.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1508.

Metallographic Examination of a Broken Ranger Engine Crankshaft Damper Plate.

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(Copy No. 11.)

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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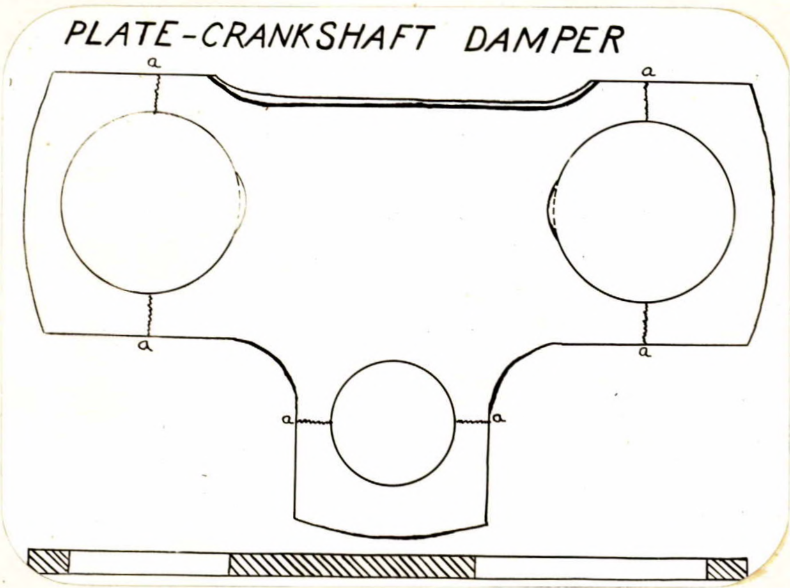
Source of Material and Object of Investigation:

On September 21st, 1943, A/C A. L. Johnson, for Chief of the Air Staff, Department of National Defence for Air, Ottawa, Ontario, submitted a Ranger Engine crankshaft damper plate which had failed in service. In the accompanying letter (File No. 935AR-2-5), it was requested that a metallurgical examination be carried out in order to determine, if possible, the cause of failure.

Macroscopic Examination:

The fracture, which appeared to be of the duplex type, took place at "aa" in each of the three large holes in the plate (see Figure 1).

Figure 1.



(Approximately ½ size).

There was, however, no way of telling which section broke first. Cracks were observed in the case at one of the fractures. The fractures definitely revealed the case-hardened outer zone. One of the fractures is illustrated in Figure 2.

Figure 2.

Core

Case

(Approximately to size).

Chemical Analysis:

Drillings taken from the core were analysed for carbon, chromium, and nickel. The following results were obtained:

		Specified	Found
		- Per cent -	
Carbon	-	0.08-0.12	0.15
Chromium	-	1.25-1.75	1.42
Nickel	-	3.25-3.75	3.36

Hardness:

The hardness of the case was determined by the Vickers method, using a 5-kilogram load, while the core hardness was determined by the Rockwell method (C scale).

		Vickers	Rockwell 'C'	Specified
Core	-	-	37½	32-43
Case	-	739	62 (by conversion)	58 min.

Depth of Case:

The depth of case, as measured by a Brinell microscope on an etched cross-section, was 0.04 inch (the outer zone darkened by the etch being taken as the case material). The finished depth of case specified in Drawing 8378 was 0.035 to 0.045 inch on ground diameters and 0.035 to 0.055 inch elsewhere.

Microscopic Examination:

Specimens cut from the plate were mounted in bakelite, polished, and examined under the microscope in the unetched condition. The steel was found to be fairly clean. The sample was next etched in a solution of 2 per cent nitric acid in alcohol and re-examined. Figure 3 is a photomicrograph, at X1000 magnification, showing the nital-etched structure of the case, which was revealed as coarse martensite. At the

(Microscopic Examination, cont'd) -

extreme outer case, and especially at the corners, there was evidence of the presence of cementite (the iron carbide phase).

Figure 3.

X1000, etched in 2 per cent nital.

STRUCTURE OF CASE.

To check for the presence of carbides, the specimen was re-polished and re-etched in Murakami's reagent. Figure 4, a photomicrograph at X500 magnification, shows the structure obtained. The black etching areas along the grain boundaries are carbides.

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(Microscopic Examination, cont'd) -

Figure 4.

X500, etched in
Murakami's solution.

SHOWING GRAIN BOUNDARY CARBIDE.

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Figure 5 is a photomicrograph, at X500 magnification, showing the nital-etched structure of the core. No free ferrite was observed in the core.

Figure 5.

X500, etch in 2
per cent nital
STRUCTURE OF CORE.

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Discussion of Results:

The duplex nature of the fracture indicates that failure has been produced by the action of alternating stresses. The chemical composition requirements were found to have been met. The examination showed that the steel had been case-hardened to the specified degree, with the case and core having the specified hardness. The coarse martensitic structure indicated that the part had been quenched from well above the upper critical temperature (i.e., probably from the carburizing temperature) and had received no subsequent refinement heat treatment. The presence of grain boundary carbides is produced as a result of too intense carburization (in the absence of subsequent diffusion heat treatment) and is a definite defect, which would certainly lower the fatigue properties of the steel. Changing the carburizing conditions, or holding above the upper critical of the case for a period in a neutral atmosphere, will eliminate these weakening carbides.

Conclusions and Recommendations:

The part failed in fatigue, and failure very probably was due to the presence of grain boundary carbides.

Better results might have been secured had the part been double-quenched, but adjustment of the carburizing conditions, or else the introduction of a diffusion heat treatment in order to effect elimination of free carbides, is definitely recommended. It is also considered that shot-blasting of the part is in order, as this treatment, if properly carried out, should definitely improve the fatigue strength.

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