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OTTAWA December 4th, 1943.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1548.

Examination of Two Broken Piston Connecting Rods.

(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

O T T A W A December 4th, 1943.

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Origin of Request and Object of Investigation:

On November 1st, 1943, two broken connecting rods were submitted by Dr. C. W. Drury, Director of Metallurgy, Army Engineering Design Branch, Department of Munitions and Supply, Ottawa, Ontario, for metallurgical examination as to cause of failure. The accompanying request form was entitled Requisition No. 602, AEDB Lot No. 389, Report No. 13, Test No. 53. The connecting rods were stated to have been made by forging.

Macroscopic Examination:

One connecting rod was fractured into two pieces, while the other was broken into three parts. Figure 1 shows one of the connecting rods "as received".

The roughness of the surface indicated that the pieces had been shotblasted.

In every case the fracture was fine-grained.

Chemical Analysis:

		Per cent
Carbon	-	0.35
Manganese	-	0.76
Silicon	-	0.12
Sulphur	-	0.041
Phosphorus	-	0.022
Nickel	-	0.03

Hardness Measurements:

Hardness measurements made on the Vickers testing machine, using a 10-kilogram load, gave results of 297 V.H.N. for one connecting rod and 203 V.H.N. for the other. However, on the harder connecting rod values as low as 213 V.H.N. were recorded close to the edge.

Micro-Examination:

The steel of both connecting rods, when examined microscopically as longitudinal and cross sections in the unetched condition, appeared to be clean.

In the case of the softer connecting rod, the structure consists of ferrite and tempered martensite, as shown in Figure 2.

In the case of the harder connecting rod, no evidence of martensitic structure could be found and the transformation products are typical of those formed at the Ar′ range of the "S" curve. Figure 3 shows the structure. Ferrite was found in a lamellar distribution in the centre of

(Micro-Examination, cont'd) -

the specimens (c.f. Figure 4) and in larger patches at the edge (c.f. Figure 5). On the same specimen, bad surface irregularities were observed, as shown in Figure 6.

Discussion of Results:

The macroscopic examination did not reveal any point of importance as to cause of failure.

The chemical analysis shows that the steel used in making the connecting rods is SAE 1035, which is a common composition for that type of part.

The hardness measurements have shown a difference of hardness for the two connecting rods submitted. An explanation as to these different hardnesses is already available from a simple metallographic analysis.

The softer connecting rod has been quenched from a temperature well under the Ac_3 point, as is shown by the composite structure, ferrite-tempered martensite. The harder connecting rod also shows ferrite, but both the mode of occurrence of this ferrite and its association with products of the Ar' range show that although the steel has reached the Ac_3 point the velocity of cooling on quenching was too slow. Moreover, the steel was decarburized, and the considerable amount of ferrite present at the edge is especially objectionable.

The irregularities at the surface are also a possible cause of failure. As shown by the distortion along these irregularities, they have apparently been formed during the shotblasting operation. These irregularities are detrimental stress raisers in a part subjected to fatigue stressing.

Parts, such as connecting rods, which require mostly fatigue strength should have a uniform structure, obtained by a proper quench-and-draw treatment. No decarburization should

(Discussion of Results, cont'd) -

be present, in order to prevent the formation of ferrite (soft constituent, at which fatigue cracking might easily start).

CONCLUSION:

The failure of the connecting rods is attributed to the ferrite precipitation resulting from improper quenching practice (i.e., quenching from too low a temperature, in one case, and too slow a quenching speed, in the other). Another detrimental feature is the presence of surface irregularities, developed by improper shotblasting practice.

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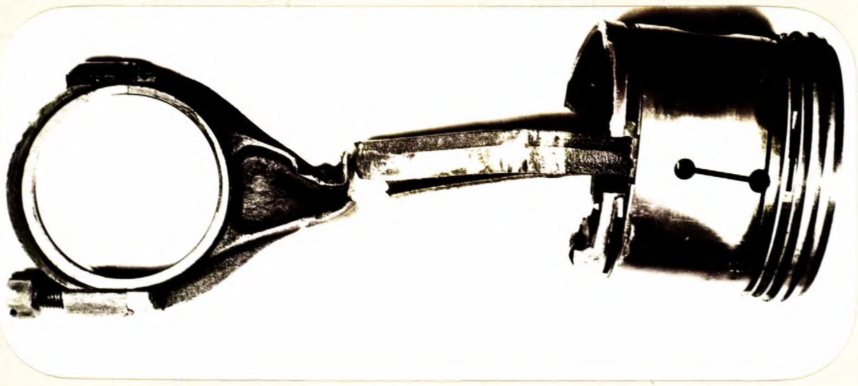
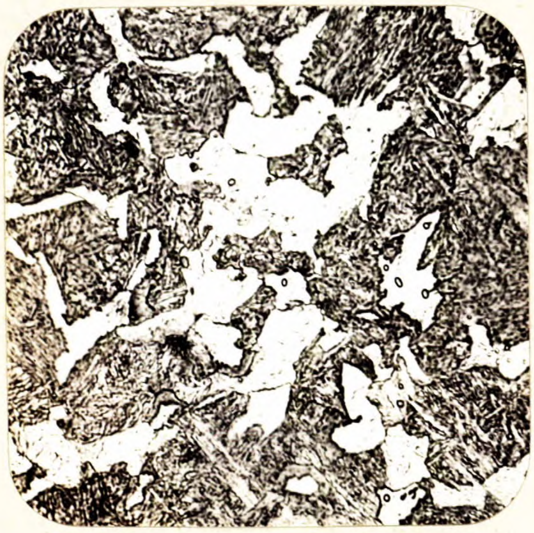
Figure 1.



SHOWING A CONNECTING ROD AS RECEIVED.

Figure 2.



X500, picral etch.

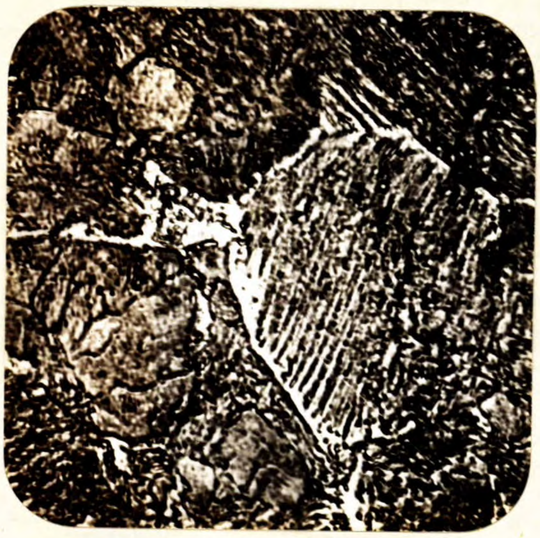
SHOWING THE COMPOSITE TEMPERED MARTENSITE-FERRITE IN THE SOFTER CONNECTING ROD.

Figure 3.

X500, picral etch.

SHOWING THE MICROSTRUCTURE OF THE HARDER CONNECTING ROD.

Figure 4.



X1000, picral etch.

SHOWING MODE OF OCCURRENCE
OF FERRITE IN THE HARDER
CONNECTING ROD (AWAY FROM EDGE).

Figure 5.

X500, picral etch.

SHOWING CONSIDERABLE
AMOUNT OF FERRITE IN
HARDER CONNECTING ROD.

Figure 6.

X200, picral etch.

SHOWING SURFACE IRREGULARITIES
IN HARDER CONNECTING ROD.

Note the distortion of metal.

AD:CHB.