File.

FILE COPY

OTTAWA   August 30th, 1943.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1487.

Examination of Cheetah Engine Master Rod Bearing.

===========

(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   August 30th, 1943.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1487.

Examination of Cheetah Engine Master Rod Bearing.

==========

Origin of Sample and Object of Investigation:

On July 24th, 1943, a letter (File No. 935U1-1-5 AMAE DAI), covering a Cheetah Engine Master Rod Bearing earlier delivered to these Laboratories, was received from Air Commodore A. L. Johnson, for Chief of Air Staff, Department of National Defence, Air Service, Ottawa, Ontario. This bearing was said to have been resurfaced with "Whitemetal" (Hoyt No. 11 alloy) and subsequently placed in an engine and run for 100 hours. The applied metal was then found to have separated from the base in some areas. Request was made for an examination to determine the probable cause.

Chemical Analysis:

In ENGINEERING ALLOYS,* the following was given as the composition of a Hoyt No. 11 alloy:

		Per Cent
Tin	-	91.4
Antimony	-	3.49
Copper	-	4.31
Lead	-	0.18
Nickel	-	0.55

It was assumed that the classification of the alloy received was correct; consequently, no analyses were made.

Macro-Examination:

A view of the half bearing as received and a close-up of one of the defective areas are given in Figures 1 and 2.

Figure 1.

HALF BEARING AS RECEIVED.
(Approximately 2/3 size).

(Continued on next page)

* "Engineering Alloys," by N. E. Woldman and A. J. Dornblatt, published by American Society for Metals, Cleveland, 1936, p. 270.

(Macro-Examination, cont'd) -

Figure 2.

CLOSE-UP OF ONE OF DEFECTIVE AREAS.
(Approximately X4).

A network of cracks was noted in regions which had become defective.

When a saw cut was made through the bearing, it was seen that there was a copper layer between the whitemetal and the steel back. In areas where the whitemetal had separated from its copper base, the copper, although present, was not noticeable. Some of the tin-base bearing alloy seemed to be still adhering to it.

Micro-Examination:

A section cut through one of the regions which had become defective was mounted in bakelite and polished. In areas where the tin-base alloy had separated from what appeared to be a copper-lead alloy back, there was still some whitemetal adhering (see Figure 3).

(Figure 3 follows, on next page)

(Micro-Examination, cont'd) -

Figure 3.

X75, unetched.

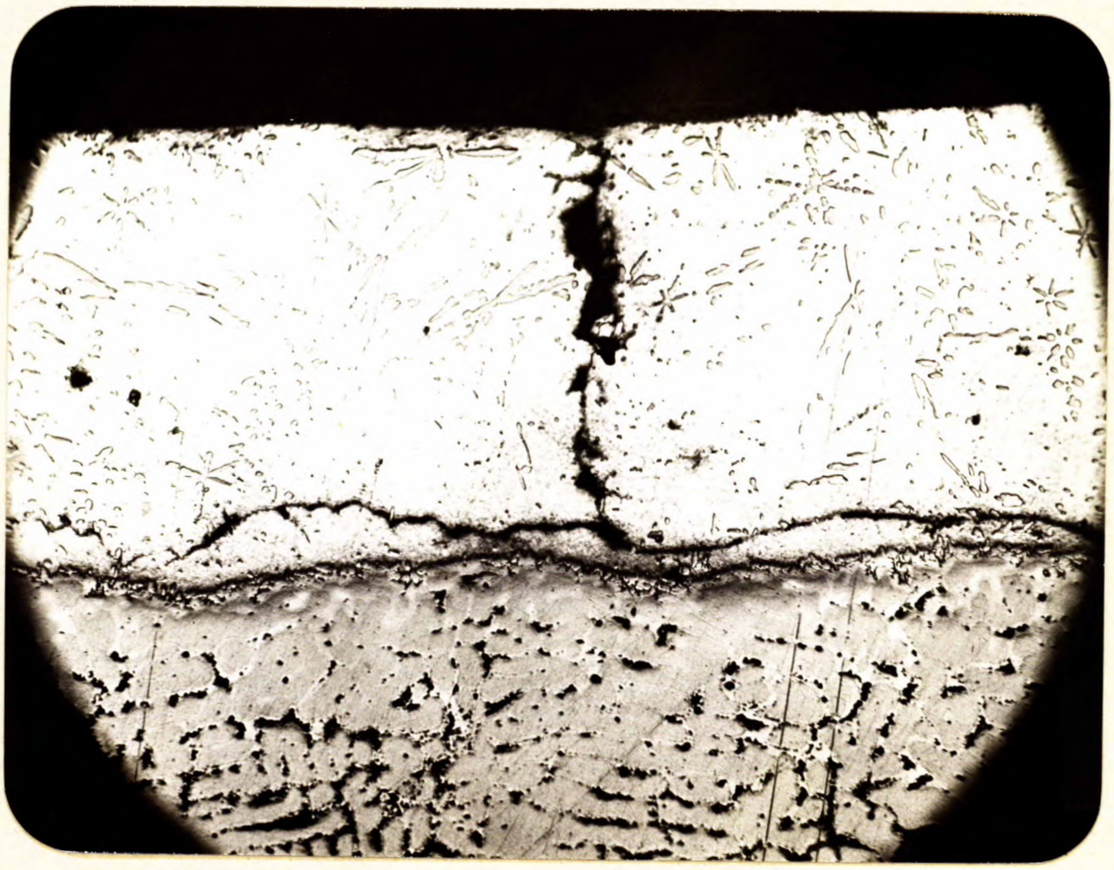
Several cracks were found to be developing in the tin-base bearing alloy. These cracks apparently began at the outer surface and developed inward until the bond was approached but not reached and then either turned at right angles or met circumferential cracks near the bond. The former of these conditions probably applies, because no circumferential cracks were found without the accompanying radial cracks. However, radial cracks which had just begun to develop were found unaccompanied. Figure 4 illustrates a typical crack at 250 diameters.

The comparatively hard particles seem to be well distributed (see Figure 4) in the matrix of this whitemetal lining. Some porosity is present, as would be expected, but it does not appear to be excessive or connected with the failure.

(Figure 4 follows, on Page 5)

(Micro-Examination, cont'd) -

Figure 4.



X250, unetched.

Discussion of Results:

Macro- and micro-examinations definitely indicate that this bearing failure was brought about by fatigue cracking of the tin-base bearing alloy. The cracks evidently developed radially inward from the outer surface of the bearing metal and turned at right angles when the bond was neared but not reached. These cracks developed until another similar one was reached and the section, thus undermined, fell out.

The bonding and structure of this tin-base bearing appear to be satisfactory.

Review of Literature on Bearings:

Figure 5 is a photographic reproduction of a photomicrograph appearing in an article, "Factors that May Determine

(Review of Literature on Bearings, cont'd) -

the Service Life of Tin-Base Bearing Metals," by D. J. Macnaughtan, F. Inst. P., in THE METAL INDUSTRY (London), Vol. 5, pp. 380-383, October 15, 1937. Commenting upon this photomicrograph in the article, he states:

"These features of the defect have resulted in a general acceptance of the view that the failure by cracking is not primarily due to brittleness of the bond but to fatigue cracking of the whitemetal itself."

Figure 5.

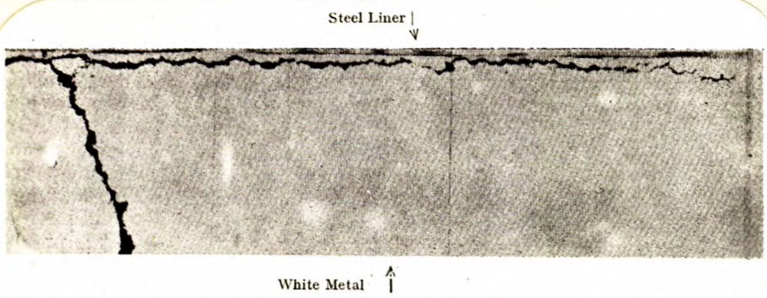


Fig. 2—Cross-section of a cracked whitemetal coating. The vertical crack has forked and continued parallel to, but just above, the bond

(Magnification unknown).

Note similarity of crack to that shown in Figure 4.

-

The following excerpts from the paper: "Automotive Bearings," by John K. Anthony, The Cleveland Graphite Bronze Co., presented at a meeting of the Detroit Section of the Society of Automotive Engineers, Detroit, Mich., March 31, 1941, appeared in the S.A.E. Journal (Transactions), Vol. 49, No. 2, August 1941:

Fatigue Resistance.

Any metallic bearing, if run under completely ideal conditions and if run long enough, eventually will fail due to fatigue, provided the load exceeds the endurance limit of that particular metal or alloy. It might be said that the bearing dies of old age.

With respect to fatigue, we can rate bearing alloys

(Review of Literature on Bearings, cont'd) -

in the following order:

1. Copper-lead.
2. Cadmium Alloys.
3. Tin-base and Lead-base Alloys (Conventional Type).

The evidence of fatigue is the presence of numerous fine cracks in the bearing metal. These cracks invariably start at the bearing surface. The first phase may be considered as the birth of the crack. In the second phase, the crack works inwardly toward the bond line, its actual path being influenced greatly by the location of the grain boundaries in the bearing metal. The third phase is quite astounding and is very probably the immediate cause of most bearing failures. Here the crack turns at right angles when it has proceeded to within a very short distance of the bond line. The crack will then run in a plane somewhat parallel to the interface between bearing metal and backing metal. When this crack meets another crack which has worked down from the surface, the effect is to produce a small section of loose bearing material. The disastrous results of a number of these small loose pieces can readily be visualized.

From the foregoing explanation on the mechanism of fatigue, it can be seen why the performance of the thin-layer bearings should be far superior to the conventional type bearing. The manufacture of thin layer bearings of the Trimetal and Micro type requires a precision and a technique not thought possible just a few years ago. However, there are many millions of both of these types of bearings in successful operation today.

Corrosion Resistance

With respect to resistance to corrosion by acids formed in the oxidation of oil, the four general alloys group themselves somewhat differently. Here the tin-base and lead-base alloys are practically immune to any type of corrosion so far encountered in the field. On the other hand, the cadmium alloys and copper-lead are definitely susceptible to attack if corrosive conditions are allowed to exist.

(End of excerpts)

CONCLUSIONS:

1. Failure of this bearing was brought about by fatigue cracking of the tin-base bearing alloy.

2. If improvement in the bearing is necessary,

(Conclusions, cont'd) -

its fatigue strength or fatigue resistance must be increased. This might be accomplished by reducing, if possible, the thickness of the bearing materials or by adopting a bearing metal with a higher fatigue limit.

oooooooooooooo
oooooo
oo

LPT:LB.