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R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1322.

Examination of a Cheetah IX Cylinder Barrel
Chromium-Plated by the Van der Horst Process.

(Copy No. 8.)

BUREAU OF MINES
DIVISION OF METALLIC MINERALS

ORE DRESSING AND
METALLURGICAL LABORATORIES

CANADA

DEPARTMENT
OF
MINES AND RESOURCES
MINES AND GEOLOGY BRANCH

OTTAWA November 6th, 1942.

REPORT

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ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1322.

Examination of a Cheetah IX Cylinder Barrel Chromium-Plated by the Van der Horst Process.

Origin of Request and Object of Investigation:

On October 23rd, 1942, these laboratories received from Squadron Leader A. J. Smith, of the R. C. A. F., Department of National Defence for Air, Ottawa, Ontario, a Cheetah IX cylinder barrel that had been built up internally by a chromium-plating procedure known as the Van der Horst process. This treatment is claimed to produce a porous chromium deposit on the surface.

The covering request letter, File No. 902-16-129 (AMAE:DAI:IM), dated October 20th, signed by Wing Comm. J. A. Easton for G/C A. L. Johnson for Chief of the Air Staff, requested that this cylinder be examined to determine the thickness and nature of the plate, and that a longitudinal section be cut out.

Macroscopic Examination:

A longitudinal section was cut out. This is shown in Figure 1. Note the bright area on the surface.

Microscopic Examination:

The plated surface was examined at a magnification of 40 diameters. At this magnification the surface appeared to be quite porous but the distribution of the porosity was not uniform. Figures 2, 3, 4 and 5, which are photomicrographs taken at a magnification of 40 diameters of the plated surface, illustrate this.

Figure 2 was taken at the shiny portion shown in Figure 1. This shows large areas of non-porous chromium plate. Figures 3, 4 and 5 show varying degrees of distribution of porosity.

Figure 6 is a view of the cross-section through the plate, showing the irregularities of the surface.

Measurement of the Thickness of the Plate:

The thickness of the plate was determined at four places along the length of the cylinder. These measurements are recorded as follows (in every case, the thickness is the distance from the top point of the chromium plate to the outer surface of the steel):

		Thickness of plate, inches.
Top of barrel	-	0.0154
Intermediate section	-	0.0075
" "	-	0.0056
Bottom of barrel	-	0.0106

The roughness of the surface was determined as the root mean square of the height of the irregularities. Sixteen measurements were taken. The resulting value, reported in micro-inches (μ inches) is 24,000. One micro-inch equals

(Measurement of the Thickness of the Plate, cont'd) -

0.000001 inch.

This value is determined in accordance with the method described in the paper, "Development of Standards for Army Ordnance Finishes," by Mary R. Norton, Associate Metallurgist, Watertown Arsenal, Watertown, Mass., published on page 703 of MECHANICAL ENGINEERING for October, 1942.

Hardness Determination:

The hardness, as measured by the Vickers hardness tester, is 536 V.P.N. Hardnesses of such deposits may very from 500 to 1100 V.P.N., depending on plating conditions.

Discussion:

The practice of building up worn surfaces by an electrodeposition of chromium is of comparatively recent development. There is an article appearing in THE AUTOMOBILE ENGINEER, August 1936, page 319, entitled "Wear Resistance, New Methods of Chromium-plating Cylinders, Crankshafts, and Cam Shafts." This article states that cam shafts and crank shafts, when properly chromium-plated, give exceptionally long life. It also states that the treatment of cylinders in this fashion promises to yield favourable results.

A later article by H. Van der Horst, "The Chrome Hardening of Cylinder Bores," MECHANICAL ENGINEERING, July 1941, page 536, gives some data on the results obtained by the Van der Horst process. The author states that in developing the process an attempt was made to apply the principle of chromium-plated cylinder bores to high speed motor car engines. The first plates deposited were dense and polished to a high finish. While wear resistance was good, scoring was bad. The answer apparently was that the surface was so smooth that

(Discussion, cont'd) -

it would not hold oil. When a very porous chromium deposit was obtained the scoring was eliminated.

The bulk of the data presented in this paper was obtained from diesel marine engines and showed that when a cylinder wall was properly treated with porous chromium plating both the cylinder wear and the piston ring wear were greatly reduced.

It is also stated in this paper that neither chrome-hardened rings nor other very hard steel rings should be run on chrome-hardened bores.

It would appear, from the information presented in this paper, that when properly done the Van der Horst process of chromium plating has definite merit. These laboratories have not had an opportunity to examine such a deposit of chromium that is known to be in good condition. However, it is the opinion of the writer that the plating on the cylinder under investigation might not be in proper condition. The porosity is uneven, as is shown in Figures 2 to 5 inclusive. A surface such as that shown in Figure 3 would certainly be desirable.

Modern developments in the field of superfinishing confirm the fact that an absolutely flat smooth surface is not desirable in any type of bearing fit, some roughness being desirable for oil adherence. A surface roughness of about 40 μ inches r.m.s. is desirable. The r.m.s. value of 24,000 μ inches, obtained on this surface, may or may not be of any significance. It is the opinion of the writer that a chromium-plated surface free from sharp peaks and containing some roughness in the form of porosity should be desirable. The surface probably should consist of about 75 per cent chromium and the balance voids. There should be no sharp peaks on the surface.

CONCLUSIONS:

1. The principle of renewing worn surfaces by rebuilding them with an electrodeposition of chromium has been proven sound in the case of crank shafts, cam shafts, deisel marine cylinders, and high speed motor car cylinders.

2. It has been shown to be necessary to have a surface that is somewhat porous.

3. The condition of the surface on the cylinder wall examined is not considered to be good. Variations in degree of porosity were very great and in many areas the surface was evidently made up of about 25 per cent chromium and 75 per cent voids.

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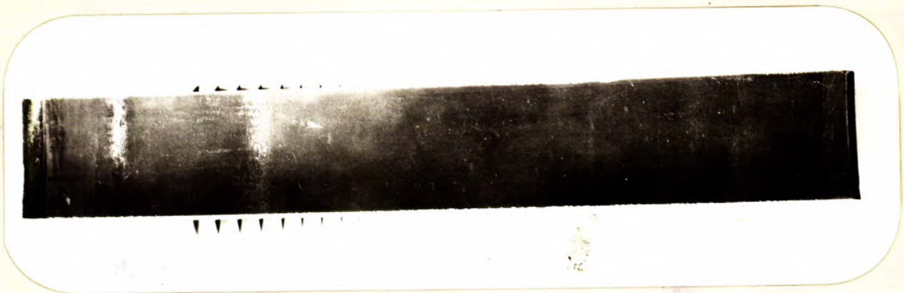
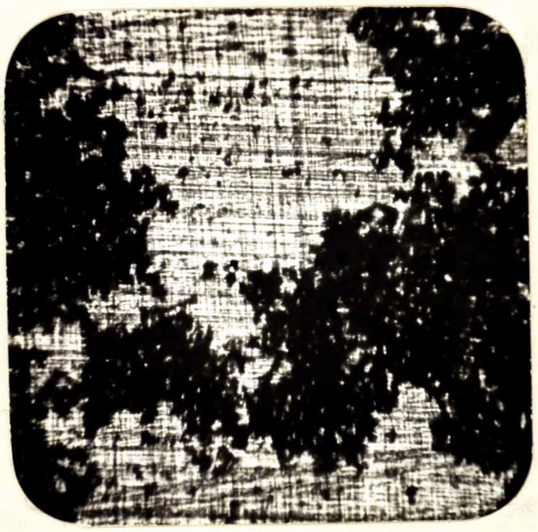
HVK:GHB.

Figure 1.



INTERNAL SURFACE OF LONGITUDINAL STRIP CUT FROM THE CYLINDER BARREL.
(Approximately ½ actual size).

Figure 2.



Magnification, X40.

PLATED SURFACE OF CYLINDER WALL.

(Note large areas of solid chromium plate.)

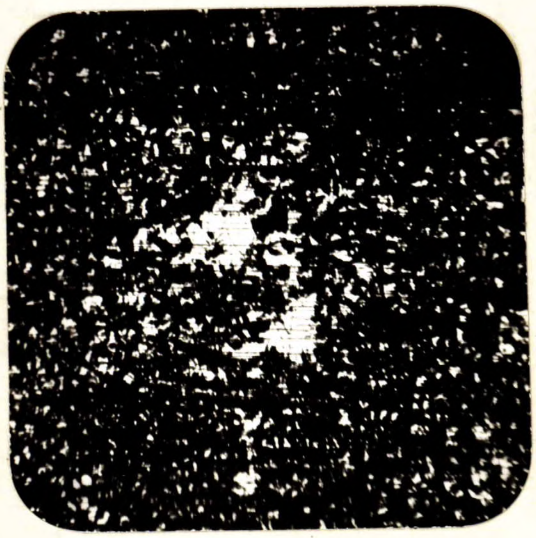
Figure 3.

Magnification, X40.

PLATED SURFACE OF CYLINDER WALL.

(Note distribution of porosity.)

Figure 4.

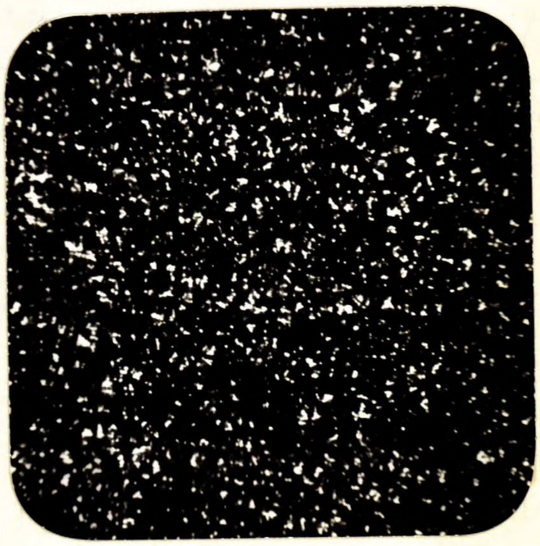


Magnification, X40.

PLATED SURFACE OF CYLINDER WALL.

(Note distribution of porosity.)

Figure 5.



Magnification, X40.

PLATED SURFACE OF CYLINDER WALL.

(Note distribution of porosity.)

Figure 6.

Magnification, X40.

CROSS-SECTION OF CHROMIUM PLATE, SHOWING SURFACE IRREGULARITIES.

HVK:PES.