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EXAMINATION OF TWO RAILWAY ROLLER BEARING RACES

by

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PHYSICAL METALLURGY DIVISION

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SUMMARY OF RESULTS

Two failed railway bearing races from the Quebec North Shore and Labrador Railway Company were examined by the Physical Metallurgy Division at the request of the Fuels and Lubricants Section, Division of Mechanical Engineering, National Research Council, Ottawa.

Examination showed that the races were manufactured from steel having the approximate composition AISI-3316 by carburization and hardening to produce a case hardness of R_c 59-64. The case microstructure, hardness and thickness were considered satisfactory. A deposit of chromium having a thickness of 0.0025 in. was observed on the housing side of the bearing race. Galling was observed on the polished working face of one race, but appeared to be absent from the grey matte working surface of the other race. Thickness of the chromium plating had been reduced in local areas, by fretting corrosion between the housing and outer race surfaces.

Further work is under way in a further attempt to identify the reason for the etched appearance of the working surface of one of the failed races.

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INTRODUCTION

On January 19th, 1960 two roller bearing races, removed after railway service with the Quebec North Shore and Labrador Railway Company, were submitted to the Physical Metallurgy Division by Mr. F. W. Smith, Fuels and Lubricants Laboratory File No. M4-R7-S1, Division of Mechanical Engineering, National Research Council, Ottawa, for metallurgical examination. The races are illustrated in Figure 1 and are identified as samples A and B. Sample A contained two "galled" areas on the inside bearing surface (arrow) but except for these marks appeared clean and polished. The bearing surface of sample B had a grey, matte appearance but exhibited less damage due to wear than sample A. The covering letter requested identification of the matte surface observed in sample B, identification of the steel and of the method of processing used in the manufacture of these bearings.

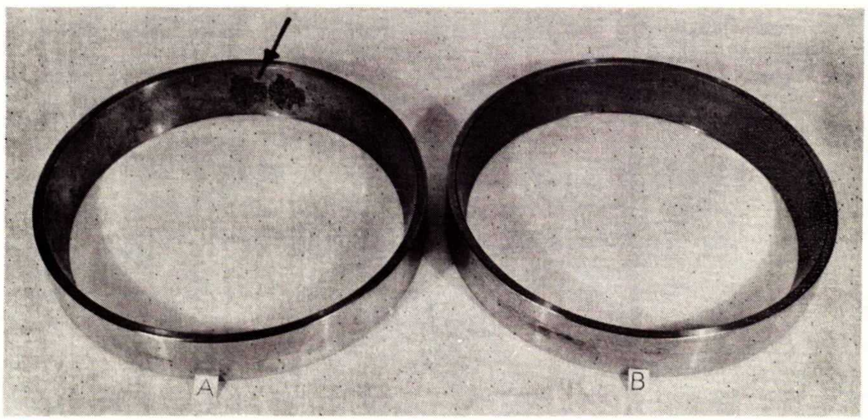


Figure 1. Timken bearing races X 1/5 approx. from the Quebec North Shore and Labrador Railway Company.

The inside, working-surface of sample A was shiny and polished but exhibited two "galled" areas (arrow). The same surface of sample B had a dull grey, matte or "etched" appearance but showed little evidence of wear.

Information supplied indicated that the two races were used as a pair in service and had operated for the same mileage at similar pressure with a common source of lubricant.

Examination showed that the outer surfaces of the races had been plated with non-porous chromium for a depth of about 0.0025 in., presumably to retard development of fretting corrosion between the race and cast iron housing surfaces.

EXAMINATION

Chemical and Spectrographic Analysis

Drillings were taken from the core metal of each race for wet chemical analysis after softening of the bearing races by a spheroidizing heat treatment. Spectrographic analyses were made on the outer race surfaces to confirm the presence of the chromium plating (visible under the microscope) on these outer surfaces.

The results of these analyses are shown in Table 1.

TABLE 1

Chemical and Quantitative Spectrographic Analysis (%)

Element	Sample A(core)	Sample B(core)	AISI 3316	Deposit on Outer Surface A	B
Carbon	0.16	0.17	0.14/0.19		
Manganese	0.42	0.44	0.45/0.60		
Silicon	0.29	0.34	0.20/0.35		
Sulphur	0.012	0.014	0.025 max.		
Phosphorous	0.008	0.010	0.025 max.		
Chromium	1.26	1.35	1.40/1.75	*P.C.	*P.C.
Molybdenum	0.10	0.11			
Nickel	2.80	3.30	3.25/3.75		
Vanadium	0.01	0.01			
*Aluminum	0.01	0.02			

P.C. - Principal Constituent

* - Quantitative Spectrographic Analysis.

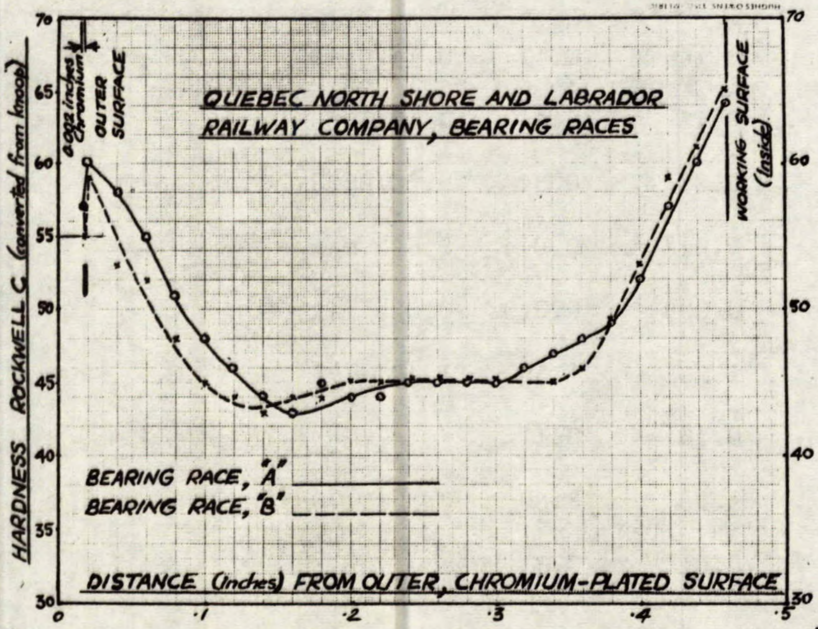
The analysis of bearing samples A and B conforms approximately to the requirements of AISI-3316.

Hardness Surveys

Transverse sections were cut through the bearing rings and Knoop hardness surveys were run from the outer, chromium-plated and carburized surface, through the core to the inner carburized working surface. The results of these surveys are shown in Fig. 2

with the Knoop hardness results converted to Rockwell C.

Figure 2



The chromium plating on the outside surface of both races had a uniform thickness of 0.0025 in. and a hardness of Rockwell C 55 to 57 except for local areas on each race where the thickness of chromium plating had been reduced to 0.0004 in. This reduction in thickness of the plating was probably caused by wear or fretting corrosion between the plated surface and the bearing housing. The only other areas where the plating was non-uniform were the corners where thicker than average (up to 0.009 in.) deposits were observed.

The total depth of carburization, for both rings at the outer surface, beneath the chromium plating, was about 0.1 in. The surface hardness of the case beneath the chromium was Rockwell C 59 to 60.

The core hardness for both rings was of the order of Rockwell C 45.

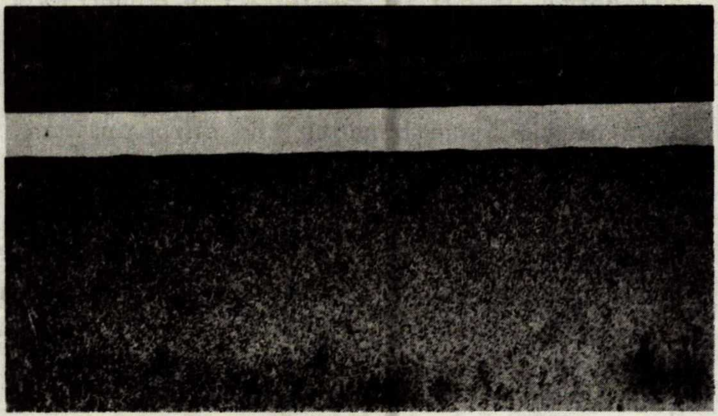
The total case depths at the inside surfaces (working surfaces) of the races was approximately 0.15 in. The hardness of the working surfaces of both races was of the order of Rockwell C 64-65.

The hardness gradient at the interface between the case and the core was gradual, providing no abrupt hardness transition.

METALLOGRAPHIC EXAMINATION

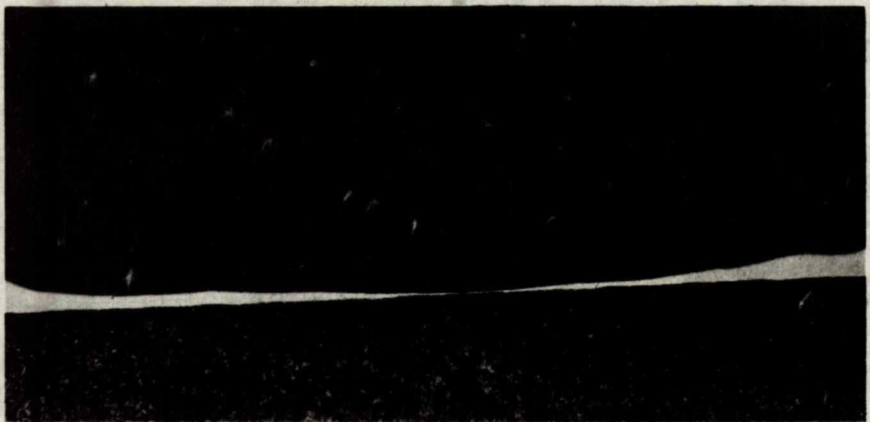
Transverse microspecimens were taken through the damaged and undamaged areas of samples A and B.

The outer surface of both races was generally undamaged and was covered with a uniform chromium deposit of 0.0025 in. except for the 0.0004 in. thin spots observed. The appearance of the unworn plating having a thickness of 0.0025 in. is illustrated in Figure 3. An area where the plating thickness has been reduced to 0.0004 in. is illustrated in Figure 4.



X100 - Etched 2% Nital

Figure 3. Typical Area of Unworn Chromium Plating.
The plating was generally similar to this material in both samples except for local areas of wear.

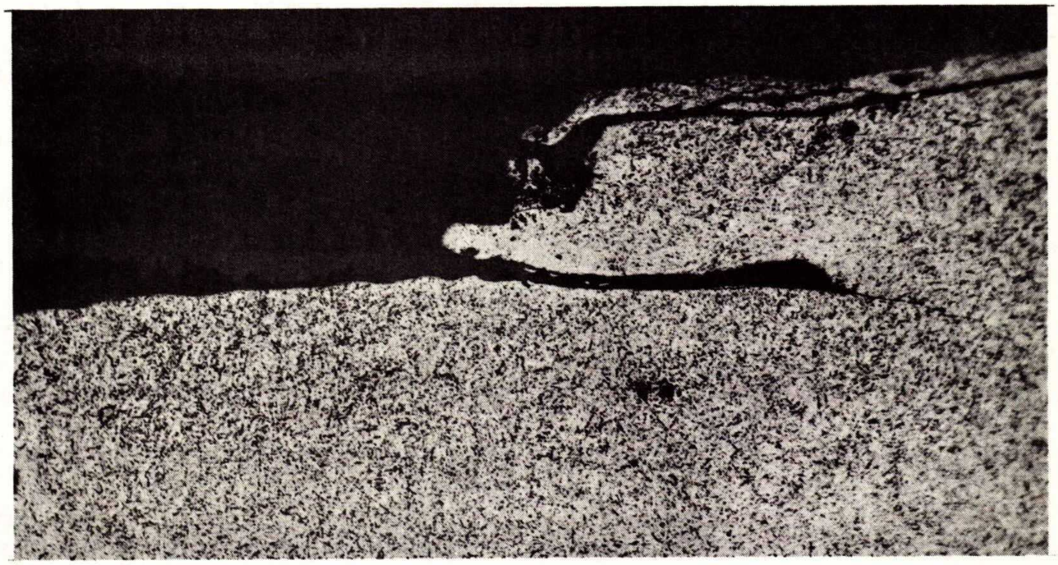


X100 - Etched 2% Nital

Figure 4. Area of Worn Chromium Plating.
Local areas similar to this were observed in both samples where the chromium plating had been reduced to 0.0004 in.

The thin spots (Figure 4) were observed in the chromium plating on the outside surfaces of both samples, and together with the "galled" areas on the working surface of sample A were probably the reason for rejection of the races from service.

Examination of the working face of sample A showed no damage except in the "galled" areas where laps and torn surface metal were visible. A transverse section through the galled area of sample A is illustrated in Figure 5.



X250 - Etched 2% Nital

Figure 5. Transverse Section Through "Galled" Area Sample A. Metal has been torn from this area by local welding or "galling" of the rubbing surfaces.

The working face of sample B did not appear to have suffered from galling. Nothing was observed to indicate severe corrosion of the working face of sample B as the cause of the "etched" appearance of this sample. However, the fact that the surface of sample B appeared to contain shallow (< 0.0001 in.) micropits whereas these were not observed on the polished surface of sample A may indicate that during manufacture or in service sample B has received a mild etching treatment. The absence of a coating, visible under the microscope, and the lack of nitride needles or sulphur concentration supports the opinion that the matte surface on sample B results from etching. (The results of the N.R.C. electron reflection examination of the bearing surfaces may assist in conclusive identification of the surface constituent). The case microstructure of both races was satisfactory but did contain traces of excess carbide in regions adjacent to the corners. The quantity and distribution of this excess carbide at corners had not affected the serviceability of the bearing races. The core microstructure of both samples consisted of tempered low-carbon martensite and appeared consistent with the core hardness of Rockwell C 45.

DISCUSSION

The bearing races were manufactured from steel having the approximate composition, AISI-3316. The steel has been carburized to give a total case depth of 0.15 in. on the working face and a case depth of 0.1 in. beneath the 0.0025 in. chromium plating on the outer surface. (The end surfaces and working faces were carburized and hardened but were not plated).

The case hardness of the working face was Rockwell C64-65, which is considered excellent for bearing surfaces. The case hardness of the outer face, beneath the plating, was slightly softer (Rockwell C 59-60) which is adequate but may reflect some heating due to wear, due to grinding of the chromium plating or some unknown manufacturing variable.

The thick case graded gradually to a core hardness of Rockwell C 45 which should provide an optimum condition of support and ductility for severe loads. The core microstructure consisted of tempered martensite and was satisfactory. The case microstructure was satisfactory and was free from excess carbides except for traces at the edge surfaces. The latter did not contribute to failure.

Comparison of the working face of the "unetched" (sample A) and the "etched" (sample B) races showed that, in the galled areas of sample A, metal had been torn from the working surface and laps had formed, typical of local-welding or galling failure, but that no galling was present on the "etched" face of sample B.

An attempt was made to determine if the grey, matte finish on the working face was caused by the presence of a coating or was an etching effect. (The latter might have been done deliberately to improve lubrication or might have occurred in service).

The matte surface was so shallow that no coating was visible under the microscope at high magnification. Also, this effect was not removed by solution with dilute sulphuric acid. A sulphur print showed no concentration of sulphides as might be expected if the surface had been sulfidized. The absence of nitride needles and the hardness results seemed to rule out nitriding as the cause of the grey surface. Examination under the microscope showed traces of surface micro-pits (less than 0.0001 in. depth) on the working surface of the "etched" sample but similar micro-pits were not observed on the polished working face which had galled.

The evidence suggests that the grey appearance is the result of some form of mild etching rather than the result of a coating procedure. (For example the use of manganese phosphate to reduce friction). Electron-reflection analyses of the etched and unetched surfaces are being made and may provide conclusive evidence about whether this appearance is due only to change in surface reflectivity as a result of etching or whether there is in fact an extremely thin, deposited coating. However, this is a difficult procedure and should, if possible, be supplemented by direct information about the manufacturing procedure.

RECOMMENDATION

* (1) Carry out electron-reflection analysis of the grey matte surface for conclusive identification of the surface constituent. * (This analysis is underway at N.R.C. but the results are not available at this time).

SUMMARY

(1) The materials used, the type of case, the case and core microstructures and hardnesses obtained are believed consistent with the requirements of high quality bearing races.

(2) The cleanness of the steel was good for air-melted quality. Small inclusions were randomly distributed and no large inclusions or clusters of inclusions were observed.

(3) The cause of the matte surface on sample B was not established although some evidence suggests that it may have been caused by some form of etching. Electron-reflection studies may assist in identification of this surface.

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