O T T A W A September 3rd, 1943.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1491.

Investigation of Low Core Hardnesses Obtained on SAE 3115 Low-Chromium Steel Universal Carrier Track Pins.

(Copy No. 19.)

Bureau of Mines
Division of Metallic
Minerals

Ore Dressing
and Metallurgical
Laboratories

CANADA

DEPARTMENT
OF
MINES AND RESOURCES

Mines and Geology Branch

OTTAWA September 3rd, 1943.

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Investigation of Low Core Hardnesses Obtained on SAE 3115 Low-Chromium Steel Universal Carrier Track Pins.

Origin of Material and Object of Investigation:

On August 16th, 1943, eighteen SAE 3115 low-chromium steel Universal Carrier track pins which had been found to have low core hardness were received from the Campbell, Wyant and Cannon Foundry Company, Muskegon, Michigan. These pins had formed part of a total of thirty-three pins picked at random from a lot of case-hardened pins suspected of being low in core hardness. Fifteen of the thirty-three pins were tested at the Campbell, Wyant and Cannon plant and the results of those tests are included in this report.

It was requested that the remaining eighteen pins be tested at these Laboratories to discover whether the core hardness could be raised to meet Specification O.A. 214 which calls for a core hardness of 24-32 Rockwell 'C' (250-297 V.P.N., converted).

INVESTIGATION AT THE CAMPBELL, WYANT AND CANNON FOUNDRY CO.

Core Hardness:

Pins which had been case-hardened by Nicarbing were reheated in an experimental furnace to 1600° F. and to 1625° F. and then oil-quenched by hand. One pin was water-quenched from 1625° F. The core hardness was determined before and after the reheating, using the Rockwell tester, 'C' scale. Table I records the results.

TABLE I.

Pin No.	Core hardness after oil quench from 1640° F., (production), Rockwell 'C'	Core hardness after additional oil quench from 1600° F., Rockwell 'C'
1	28 - 27 - 27	12.5 - 13 - 10 - 10.5
2	16 - 17 - 13.5 - 14	5 - 6.5 - 6.5 - 8.5
3	9 - 8 - 9	
5	4.5 - 6.5 - 7.5	
6	15.5 - 17.5 - 15.5	
7	13.5 - 12 - 12	8.0 - 12.5 - 11 - 12
8	7.5 - 7 - 6.5	8 - 8.5 - 10 - 9.5
10	17.5 - 21 - 19	
12	12 - 11.5 - 14	9.5 - 11 - 11 - 9.5
15	7 - 8.5 - 9	5 - 5 - 6.5 - 5

Pin No.	Core hardness after oil quench from 1640° F., (production), Rockwell 'C'	Core hardness after additional oil quench from 1625° F., Rockwell 'C'
4	13.0 - 12.0 - 12.0	11.0 - 11.0 - 14.5 - 13.0
11	11.5 - 13.5 - 13.0	9.0 - 11.0 - 11.0 - 11.5
13	9.0 - 12.0 - 14.5	11.0 - 11.0 - 11.0 - 11.5
14	7.5 - 8.5 - 9.0	7.0 - 8.0 - 9.0 - 6.5

Pin No.	Core hardness after oil quench from 1640° F., (production) Rockwell 'C'	Core hardness after water quench from 1625° F., Rockwell 'C'
5	4.5 - 7.5 - 6.5	24.0 - 25.0 - 26.0 - 25.0

Chemical Analysis:

Pin No.	Carbon	Manganese	Chromium	Nickel
		- Per cent -		
1	0.194	0.56	0.16	1.29
5	0.13	0.52	0.17	1.15
8	0.146	0.54	0.18	1.14
10	0.212	0.57	0.17	1.20

INVESTIGATION AT BUREAU OF MINES O.D.M.L., OTTAWA.

Core Hardness:

The core hardness was taken on the pins as received, using the Vickers hardness tester with a 50-kilogram load. The surface hardness was taken using the Rockwell tester, 'A' scale. The results are listed below:

Pin No.	Surface hardness, Rockwell 'A'	Core hardness, V.P.N.
18	80 - 82	184
20	80.5 - 83	220
21	79 - 82	210
24	80.5 - 83	230
25	79 - 81	193
26	80 - 81.5	210
27	81 - 82	215
28	80 - 82	204
29	80.5 - 82	208
30	80.5 - 81	229
31	79 - 80.5	163
32	81 - 82.5	207

Chemical Analysis:

Chemical analyses were made on drillings from the cores of three soft-core and three intermediate-core pins. The results of the analyses, together with the core hardnesses, appear in Table II.

(Continued on next page)

(Chemical Analysis, cont'd) -

TABLE II.

Pin No.	Core hardness, V.P.N.	Carbon	Manganese	Chromium	Nickel
		- Per cent -			
18	184	0.13	0.46	0.21	1.20
20	220	0.18	0.52	0.16	1.25
24	230	0.18	0.50	0.15	1.28
28	204	0.13	0.46	0.24	1.19
30	229	0.18	0.52	0.17	1.36
31	163	0.13	0.45	0.22	1.19

Heat Treatment:

Five soft-core pins were cut in half and a half-piece of each was heated in a neutral atmosphere in a Vapocarb furnace at temperatures of (1) 1575° F., (2) 1600° F., (3) 1625° F., (4) 1650° F., and (5) 1700° F. The pieces were held at temperature for 20 minutes and quenched in Houghton's No. 2 oil at 110° F. Core and surface hardnesses were taken before and after heating. The core hardnesses were taken at the central cross-section of the half-piece. The results appear in Table III below:

TABLE III.

	BEFORE HEATING			AFTER HEATING	
Pin No.	Surface Hardness, Rockwell 'A'	Core Hardness, V.P.N.	Temperature, in degrees F.	Surface Hardness, Rockwell 'A'	Core Hardness, V.P.N.
18	80-82	184	1575	81-82	200
21	79-82	210	1600	82.5-83	227
26	80-81.5	210	1625	84	258
28	80-82	204	1650	83.5-84	236
31	79-80.5	163	1700	84-84.5	226

Microstructure:

Transverse sections were cut from two pins, No. 25 (core, 193 V.P.N.) and No. 30 (core, 229 V.P.N.). The sections were polished, etched in nital, and examined under the microscope. Figures 1 and 2, taken at 500 magnifications, show the core

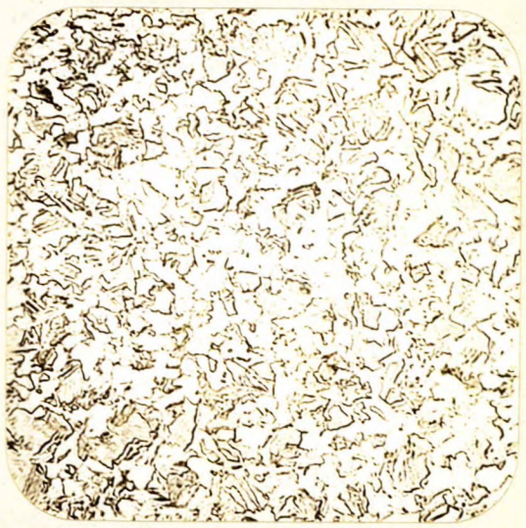
(Microstructure, cont'd) -

structures.

Figure 1.

X500, nital etch.
CORE OF PIN (193 V.P.N.).

Figure 2.



X500, nital etch.
CORE OF PIN (229 V.P.N.).

Note difference in amounts of pearlite.

Discussion:

Investigation at Campbell, Wyant & Cannon Foundry Co.

Of the pins selected, all but one had core hardnesses below the 24-32 Rockwell 'C' range required by Specification O.A. 214. It should be noted that results obtained in the low range of the Rockwell 'C' scale are not accurate but the results reported here definitely do show the pins to have very low core hardness.

Reheating and oil-quenching the pins at lower temperatures under experimental conditions did not give any increase in core hardness but, rather, tended to lower it, especially when the pins were oil-quenched from 1600° F. Reheating and water-quenching raised the core hardness, as is to be expected, due to the more drastic quench. Water-quenching,

(Discussion, cont'd) -

however, would not lend itself readily to production, as the problem of warpage arises.

The chemical analyses conformed with the modified specification for SAE 3115 steel. The carbon content affects the core hardness. When the core hardness is low, the carbon content is found to be low.

Investigation at Bureau of Mines O.D.M.L., Ottawa.

None of the pins tested had core hardnesses above the 24 Rockwell 'C' (250 V.P.N. converted) minimum required by Specification O.A. 214. All pins had satisfactory surface hardness.

The chemical analyses conformed with the modified specification for SAE 3115 steel. These analyses substantiate the point mentioned before, that the core hardness depends on the carbon content; mainly, however, the addition of more chromium would aid the hardenability and consequently produce a harder core.

The half-pins reheated and oil-quenched showed a slight increase in core hardness. This increase may have been due either to the fact that a half-pin was used, or because the quenching oil used in these Laboratories (Houghton's No. 2) gives a slightly higher cooling rate than that used by Campbell, Wyant and Cannon. However, in only one instance was the core hardness above the minimum specified. It is felt, then, that the minimum core hardness required cannot be obtained by oil-quenching pins of the composition tested. Examination of the microstructure of the pins showed that as the core hardness decreased the amount of pearlite decreased. This is to be expected, from the results of the chemical analyses.

CONCLUSIONS:

1. Core hardnesses obtained by the Campbell, Wyant and Cannon Foundry Company were, in all instances but one, below the minimum specified.

2. Satisfactory surface hardness was obtained for all pins.

3. Reheating and oil-quenching the pins does not raise the core hardness to the required minimum of 24 Rockwell 'C'.

4. The chemical analyses conform to the modified specification for SAE 3115 steel.

5. Variation of the carbon content of the steel within the limits of the specification causes a corresponding variation in the core hardness of the pins. A higher chromium content would result in a higher core hardness, due to the increased hardenability.

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