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REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1634.

Metallurgical Examination of Universal Carrier
Track Pins made from NE 8620 Steel.

(Copy No. 17)

Bureau of Mines
Division of Metallic
Minerals.
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Ore Dressing
and Metallurgical
Laboratories

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
Mines and Geology Branch

OTTAWA May 3rd, 1944.

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Investigation No. 1634.

Metallurgical Examination of Universal Carrier Track Pins made from NE 8620 Steel.

Origin of Request and Object of Investigation:

Ten Universal Carrier track pins made from NE 8620 steel were submitted to these Laboratories by the Detroit, Michigan, office of the Inspection Board of the United Kingdom and Canada on April 17th, 1944. It was requested that the routine physical tests be made on these pins to determine whether or not they would conform to Specification O.A. 214.

In a covering letter (dated April 15th, 1944, File No. 10/C/1), Captain V. J. Sharkey, for Director, Tanks and M.T. Division, Inspection Board of United Kingdom and Canada, Detroit, Michigan, stated that the cores of the pins submitted had hardnesses of around 40 Rockwell 'C' and above.

These pins were made for the Auto Specialties Manufacturing Company, St. Joseph, Michigan, for assembly in their track.

It was thought that for purposes of comparison it would be useful to test some pins made from SAE 3115 steel. The pins of this type that were tested had been treated by the Commercial Steel Treating Corporation, Detroit, Michigan, and were representative of their production in December, 1942. It should be noted that these pins were produced before Specification O.A. 214 was issued.

Macroscopic Examination:

A longitudinal section of one of the pins made from NE 8620 steel, when deep etched for 15 minutes in boiling 50 per cent hydrochloric acid, failed to show any sign of laminations.

Chemical Analysis:

The chemical analysis of the pins, together with their respective specifications, are shown below:

		Pins from SAE 3115 steel	Specification* for SAE 3115 steel	Pins from NE 8620 steel	Specification for NE 8620 steel
			- Per Cent -		
Carbon	-	0.18	0.13-0.18	0.22	0.18-0.23
Manganese	-	0.48	0.30-0.60	0.84	0.70-0.95
Silicon	-	0.29	---	0.29	0.20-0.35
Nickel	-	1.22	1.0 - 1.5	0.71	0.40-0.60
Chromium	-	0.40	0.25-0.45	0.52	0.40-0.60
Molybdenum	-	-	---	0.20	0.15-0.25

Physical Properties:

The case depth, surface and core hardness values for the pins made from NE 8620 steel are given in Table I. Similar values for the pins made from SAE 3115 steel are listed in Table II.

Impact tests were made on the pins, using a 50-pound weight having a 13/32-inch-radius block as a plunger. This weight was dropped from various heights giving impact values ranging from 45 to 60 foot-pounds. The pins were freely supported at 8-inch centres and all pins tested (10 pins made from NE 8620 steel and 15 pins made from SAE 3115 steel) were subjected to impact blows until they either broke or were so badly bent that they would not rest on the supports. The results of the impact tests are shown in Tables I and II.

The thickness of the case for both types of steels was measured on all pins examined. The values obtained are also shown in Tables I and II.

(Tables I and II follow, on Page 3.)
(Text continues on Page 4.)

* Specification, as at present proposed, for purchases of this type of steel.

TABLE I. - PINS MADE FROM NE 8620 STEEL.

Pin No.	2410	2411#	2412Ø	2413	2414	#2415*	2416	2417Ø	2420	2422
Surface hardness, Rockwell 'A'	80-81	82	79-81	80	81-82	82-84	82-85	82-84	80-81	81-83
Core hardness, Rockwell 'C'	47-48	40-43	40-41	40-41	39-41	48-49	42	39-41	45-47	45-47
Case thickness, inches	0.012	0.010	0.010	0.009	0.014	0.010	0.008	0.012	0.008	0.010
Impact Tests:										
Blows, foot-pounds	50	45	45	45	50	45	60	45	60	45
No. of blows to break	2	2	5	3	2	6	1	4	1	1

TABLE II. - PINS MADE FROM SAE 3115 STEEL.

Pin No.	1	2	3	#4*	5	6*	7	8	#9*	10*	11	12	13	14*	15
Surface hardness, Rockwell 'A'	79-80	76	81-82	76	78-79	79-81	81-82	78-79	80	78	76-78	79	81-84	76-79	82
Core hardness, Rockwell 'C'	28-31	24-27	28-30	18-20	28-30	16-18	31	16-19	15-18	16-18	15-16	17-18	26-28	15	29
Case thickness, inches	0.008	0.012	0.012	0.012	0.010	0.008	0.008	0.012	0.012	0.014	0.009	0.010	0.008	0.011	0.010
Impact Tests:															
Blows, foot-pounds	45	45	45	45	45	45	50	50	60	50	55	55	55	60	60
No. of blows, to break	2	4	1	5	2	5	2	5	3	4	3	3	1	3	1

Legend:

- * Pin unbroken in impact test.
- # Pin sectioned for microscopic examination.
- Ø Pin broken on impact machine using 11.2 pound weight.

(Physical Properties, cont'd) -

TABLE III. - SUMMARY OF TABLES I AND II.

Test	Pins made from NE 8620 steel	Pins made from SAE 3115 steel
Maximum surface hardness, Rockwell 'A'	85	84
Minimum " " " 'A'	79	76
Average " " " 'A'	81.6	79
Maximum core hardness, Rockwell 'C'	49	31
Minimum " " " 'C'	39	15
Average " " " 'C'	43.3	22.3
Maximum case thickness, inches	0.014	0.014
Minimum " " "	0.008	0.008
Average " " "	0.010	0.010

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Microscopic Examination:

Transverse sections were cut from representative pins made from both steels. These sections were mounted, hand polished, etched, and microscopically examined.

The core of the pins made from NE 8620 steel was martensitic throughout. Figure 1, at a magnification of 500 diameters, is a representative field showing this structure. The case on these pins was martensite with possibly some retained austenite (see Figure 2, at a magnification of 500 diameters).

The core of the pins made from SAE 3115 steel was low-carbon martensite and ferrite. Figure 3, at a magnification of 500 diameters, is a representative field showing this structure. The case on these pins was martensite (see Figure 4, at a magnification of 500 diameters).

Discussion of Results:

The chemical analysis of the pins made from NE 8620 steel showed slightly more nickel than was required by the specifications. This is not considered important. The analysis

(Discussion of Results, cont'd) -

showed that the pins made from SAE 3115 steel agreed with the purchasing specification.

Both the core and case structures of the NE 8620 pins appear satisfactory. The SAE 3115 pins have considerable ferrite in the core. This would indicate that these pins had been quenched from below the upper critical temperature of the core. These pins could be improved by heating to above the critical temperature of the core and then quenching in a well-agitated oil bath. If this were done, the amount of ferrite would be lessened considerably. Since fatigue in pins may start at the transition zone, a properly quenched core structure containing the minimum amount of ferrite should be achieved. The transition zone would then be of a structure more resistant to fatigue.

The core structure and resultant higher hardness of the NE 8620 pins is more desirable from the point of view of fatigue resistance. It must be pointed out, however, that resistance to impact is a factor in pin performance. Previous experience indicates that thick-cased pins fail in service. If failure were due to fatigue only, the pins in service should not have failed at much earlier mileages than the lighter cased pins. It may be assumed that the thick-cased pins failed mainly due to impact, despite the fact that the fracture may be of the usual duplex "fatigue" type. The impact stresses may crack the case, which in time brings about rapid progressive failure. Specification O.A. 214 was drawn up to balance the various factors.

Most of the NE 8620 pins, although of high core hardness, pass the 45 foot-pound specified drop impact. These pins, however, were of the thin-cased variety, 0.008 to 0.014 inch. Should the specified case depth (0.012-0.020) be met at the

(Discussion of Results, cont'd) -

high side, e.g. 0.017 to 0.020, it would be extremely doubtful whether the pins would pass the impact requirement (see Report of Investigation No. 1631, April 27th, 1944).

The present-production SAE 3115 pins have the specified core hardness of 24 to 32 Rockwell 'C' and they pass the impact requirement for the <u>whole range of case depth</u>. Should it be demonstrated that the NE 8620 pins can pass the specified impact, <u>notwithstanding the core hardness</u>, for the <u>whole range of case depth</u>, then, it is felt, an excellent cased pin will have been produced. If, however, a thin case will have to be resorted to, in order to meet all the specified requirements, it can be expected that the pin will wear through the case at a lower mileage.

It may be said that the thin-cased, high-core-hardness pin is approaching the homogeneous pin. It has the following disadvantages, however:

1. It contains much more residual stress than the homogeneous type of pin.
2. The hard case is subject to notch sensitivity.
3. After the case has worn away a softer and less wear-resistant surface is exposed than in the homogeneous pin.
4. The possibility always exists that the pin may bend past the case break point in service.

<u>CONCLUSIONS</u>:

1. The chemical compositions of the NE 8620 and the SAE 3115 steel pins agree approximately with their respective specifications.

2. No laminations were found on examination of a longitudinal section of one of the pins made from NE 8620 steel.

3. The case (surface) hardness range of the NE 8620

(Conclusions, cont'd) -

steel pins was 79-85 Rockwell 'A'; that of the SAE 3115 steel pins was 76-84 Rockwell 'A'.

4. The core hardness range of the NE 8620 steel pins was 39-49 Rockwell 'C' and that of the SAE 3115 steel pins was 15-31 Rockwell 'C'.

5. The range of the case depth on the NE 8620 steel pins was 0.008-0.014 inch. An exactly similar range was found on the SAE 3115 steel pins.

6. Seven out of 10 pins made from NE 8620 steel passed the 45-foot-pound blow impact requirement. Two of the pins were tested and broke under a blow of 60 foot-pounds; they might or might not have broken under a 45-foot-pound blow. Twelve of the 15 pins made from SAE 3115 steel passed this requirement. One of these pins broke on a 55- and one on a 60-foot-pound blow. Nothing can be said as to whether these two pins would have passed a blow of 45 foot-pounds.

7. The core and case structures of the NE 8620 pins are satisfactory.

8. The NE 8620 pins should have better fatigue resistance than the SAE 3115 pins, due to the hard core.

9. Thick-cased (0.017-0.020 inch) NE 8620 pins having high core hardness should be tested for impact.

10. The SAE 3115 pins examined have not been properly heat-treated, as a relatively large amount of ferrite is present. This constituent may have a deleterious effect on the fatigue life of the important transition zone.

11. The SAE 3115 pins should be quenched from above the critical point of the core into a well-agitated oil bath.

Recommendation:

In order to ensure passing the various requirements of Specification O.A. 214, NE 8620 pins, due to high hardenability, will have to be produced with a case depth toward the minimum, 0.012 inch, called for by the specification. It is felt that case depths of 0.017 to 0.020 inch will produce brittle pins, as was shown in Investigation No. 1631, April 27th, 1944.

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PINS MADE FROM NE 8620 STEEL.

Figure 1.

X500, nital etch.

CORE STRUCTURE.

Low-carbon martensite.

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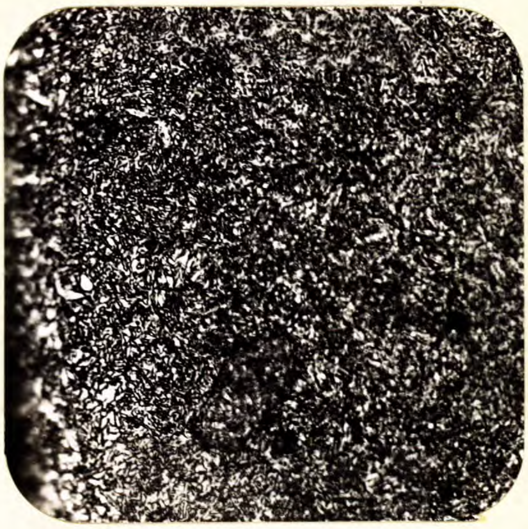
Figure 2.



X500, nital etch.

CASE STRUCTURE.

Structure, martensitic.

Note: Outside wall at left. White structure is probably retained austenite.

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PINS MADE FROM SAE 3115 STEEL.

Figure 3.

X500, nital etch.

CORE STRUCTURE.

Low-carbon martensite and ferrite

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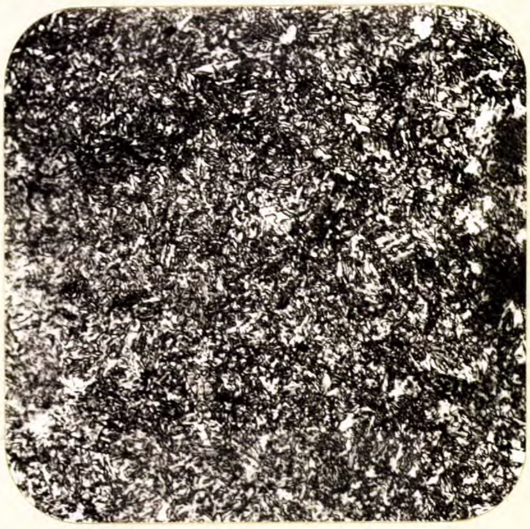
Figure 4.



X500, nital etch.

CASE STRUCTURE.

Structure, martensitic.

Note: Outside wall at left.

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ELC:SLG:GHB.