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R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1419.

Examination of NE 8640 Steel for
Homogeneous Track Pins.

(Copy No. 18.)

CANADA

DEPARTMENT
OF
MINES AND RESOURCES

Mines and Geology Branch

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Origin of Material and Object of Investigation:

Field tests carried out in the summer of 1942 at Windsor, Ontario, established the fact that homogeneously hardened pins of SAE 9255 steel were satisfactory for use in the Universal Carrier. This steel consequently was approved for production. In the U.S.A., however, difficulties were being encountered in obtaining SAE 9255 bar stock and NE 8640 was offered as a substitute material. Since field tests take considerable time, a long delay would ensue from waiting for their results. However, inasmuch as laboratory drop and impact tests have been found, in the past, to correlate with field test results, it was decided to obtain a sample length of NE 8640 steel and subject it to the standard laboratory tests after heat treatment. Six feet of bar stock, to be used in such tests, was received from the Republic Steel Corporation, Detroit, Michigan, on March 19th, 1943.

Bar Stock Received:

The hardness of the bar stock was 25-26 Rockwell 'C'. The diameter of the bar was 0.760 inch. The structure was pearlitic and there was no visible decarburization.

Physical tests were carried out on a 0.505-inch-diameter tensile specimen taken from the bar stock. The results were:

Tensile strength, p.s.i.	-	133,000
0.2 per cent proof stress, p.s.i.	-	91,200
Elongation in 2 inches, per cent	-	19
Reduction in area, per cent	-	46
Brinell hardness	-	269

Chemical Analysis:

	As Found	Specification NE 8640
	- Per cent -	
Carbon -	0.38	0.38-0.43
Manganese -	0.87	0.75-1.00
Silicon -	0.35	0.20-0.35
Chromium -	0.49	0.40-0.60
Nickel -	0.47	0.40-0.70
Molybdenum -	0.20	0.15-0.25
Sulphur -	0.019	0.050 max.
Phosphorus -	0.010	0.040 max.

Heat Treatment:

(a) Two pins (12-inch lengths cut from the bar stock) were quenched in water from 1525-1550° F.

Rockwell 'C', No. 1: 53-56.
No. 2: 53-55.

(b) Two pins were quenched in 90° F oil from 1525-1550° F.

Rockwell 'C', No. 3: 49.
No. 4: 50-51.

The four pins were drawn to get a hardness of 48 ± 3 Rockwell 'C'. Pins Nos. 1 and 2 were drawn at 550° F. The hardness obtained was 46-48. Pins Nos. 3 and 4 were drawn at 350° F. The hardness was 49-51.

Bend Tests:

Bend tests were carried out on the Amsler Universal machine using a 12-inch radius and 8-inch centres. Table I lists the results obtained with a water-quenched and an oil-quenched pin. The method of obtaining elastic limit, permanent bend, and case break point is outlined in O.D.M.L. Report of Investigation No. 1197, April 2nd, 1942.

Table I.

	Water-quenched Pin		Oil-quenched Pin	
	Deflection, inches	Load, pounds	Deflection, inches	Load, pounds
Elastic limit -	0.160	6,250	0.175	6,650
Permanent bend -	0.310	8,200	0.325	9,450
Case break point -	1.80 Unbroken at 13,350 lb.		0.478	10,200
Rockwell 'C' -	46-48		49-57	

Drop Impact Tests:

A 50-lb. weight was dropped from 180 cm. on a water-quenched and on an oil-quenched pin. Both pins passed this test.

Hardness Survey:

Transverse sections were cut from both types of heat-treated pin. A hardness survey was made across the face, using the Vickers machine and a 10-kilogram load.

1. Water-Quenched Pin:

Distance from the surface, inches -	Surface	0.04	0.13	0.29	0.37	0.27	0.19	0.14	0.05	Surface
Vickers hardness No. -	464	530	542	578	519	519	505	536	542	[illegible]

2. Oil-Quenched Pin:

Distance from the surface, inches -	Surface	0.07	0.15	0.25	0.35	0.34	0.25	0.15	0.05	Surface
Vickers hardness No. -	433	599	620	572	585	519	592	620	592	405

Microscopic Examination:

Transverse microspecimens were cut from the two types of pins. Figures 1 and 2, taken at X1000, illustrate the structures obtained. It can be seen that the water-quenched pin has a finer tempered martensitic structure than the oil-quenched pin.

Figure 1.

X1000, nital etch.
OIL-QUENCHED PIN.

Figure 2.

X1000, nital etch.
WATER-QUENCHED PIN.

AUSTEMPERING EXPERIMENTS.

Austempering heat treatments were tried in order to determine whether it would be possible to obtain a higher hardness pin and still retain the favourable bend and impact properties. Time quench experiments were carried out. Pieces of the pins (about 3 inches in length) were quenched in water for 5, 6, and 7 seconds, then transferred to a salt bath of 47 per cent sodium nitrite and 53 per cent potassium nitrate and held at 400° F. for five hours.

The purpose of the time quench experiments is to

(Austempering Experiments, cont'd) -

avoid the 'nose' of the "S" curve by first water-quenching. The work is then transferred to the salt bath for isothermal transformation.

Heat Treatments.

No. 1 -

Water-quenched from 1525-1550° F. for 5 seconds. Transferred to salt bath at 475° F. for 5 hours, then water-quenched. Hardness obtained - 26-33 Rockwell 'C'.

A transverse section was cut and examined microscopically. Figure 3, taken at X1000, illustrates the structure obtained with this treatment. Ferrite has not been entirely eliminated, indicating that 5 seconds in water is not sufficient time.

Figure 3.

X1000, nital etch.

STRUCTURE OF 5-SECOND WATER-QUENCHED SAMPLE IN 475° F. SALT.

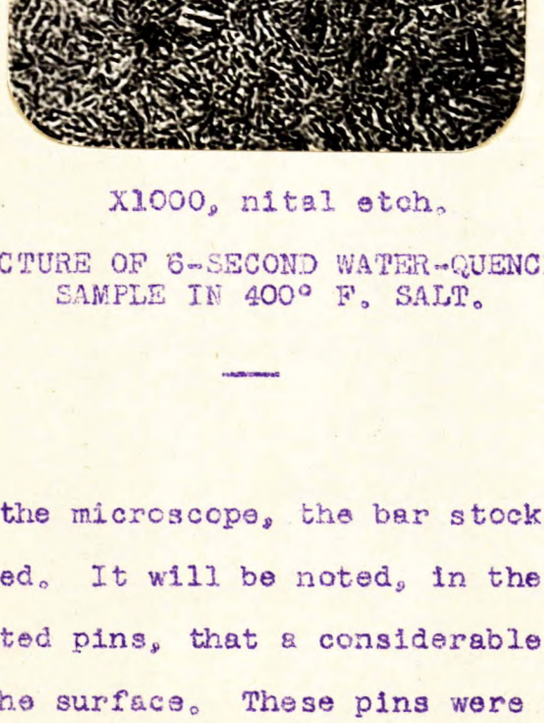
No. 2 -

Water-quenched from 1525-1550° F. for 6 seconds. Transferred to salt at 400° F. for 5 hours, then water-quenched. Figure 4 (X1000) illustrates the structure obtained

(Austempering Experiments, cont'd) -

on microscopic examination. The ferrite has been eliminated. However, a martensitic structure has been obtained, not bainite. The hardness of this piece was 46-52 Rockwell 'C'. The results of this examination indicate that it is impossible to time-quench NE 8640 to a high enough hardness, 53 ± 3 Rockwell 'C', and obtain the favourable properties conferred by the bainite structure. The above treatment, for example, produced a pin of 46-52 Rockwell 'C' at 400° F. and it was in the martensite range. It is consequently impossible to obtain a harder pin without encountering martensite.

Figure 4.



X1000, nital etch.

STRUCTURE OF 6-SECOND WATER-QUENCHED SAMPLE IN 400° F. SALT.

Discussion:

Under the microscope, the bar stock did not appear to be decarburized. It will be noted, in the hardness survey of the heat-treated pins, that a considerable drop in hardness occurs towards the surface. These pins were all heat-treated in the Vapocarb furnace, using a neutral atmosphere. It is

(Discussion, cont'd) -

consequently felt that lower-carbon material must have been present near the surface. A carburizing atmosphere will have to be employed to eliminate this decarburized zone. An 0.50 per cent carbon steel is desirable, as it gives better wear resistance. Recarburizing to eliminate the decarburization will tend to give a higher carbon content at the surface in this steel than 0.38. Care must be taken not to overcarburize. The high silicon content in SAE 9255 helps to prevent this but high silicon is not present in NE 8640.

The steel conforms chemically to the specification limits for NE 8640. The physical properties of the bar stock are satisfactory.

The stock can be either water- or oil-quenched. The latter produces a hardness of 49-51 in the quenched condition even though the carbon is at the lower limit, namely, 0.38. It must be remembered, however, that a stress-relieve draw should be applied. The water-quenched pin gave better bend properties but it was of a lower hardness. The drop impact test indicated that both types were equally satisfactory. If warpage can be avoided, water quenching is preferable, as it necessiates a higher draw temperature.

It is not possible to austemper this steel. The carbon content appears to be too low for this type of treatment.

CONCLUSIONS:

1. The bar stock has satisfactory physical properties and conforms to the chemical limits specified for this steel.

2. The steel may be either oil- or water-quenched. The latter gives slightly better bend properties and is preferable.

3. The decarburization must be eliminated by a carburizing treatment.

4. The drop impact tests were satisfactory.

5. The steel cannot be austempered in 0.760-inch-diameter bars.

6. NE 8640 bar stock should make a satisfactory homogeneous pin.

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