O T T A W A October 1st, 1941.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1103.

Examination of "TOCCO" (Induction) Hardened Track Pins for Mark III Tanks.

BUREAU OF MINES
DIVISION OF METALLIC MINERALS
—
ORE DRESSING AND
METALLURGICAL LABORATORIES

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
MINES AND GEOLOGY BRANCH

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Object of Investigation:

The poor results obtained from "TOCCO" (induction) hardened track pins led to a request (from W. L. Auchincloss, Inspector of Tanks, Inspection Board of the United Kingdom and Canada, 58 Lyon Street, Ottawa, on September 24th, 1941) that an examination be carried out to determine, if possible, the reason for their failure. A pin of this type, produced by the Cockshutt Plow Company Limited, was received on September 26th, 1941.

Description:

These pins are 0.875 inch in diameter and 11.88 inches long. Present specifications call for British 5005/102 steel, which is required to be as follows:

		Per cent
Carbon	=	0.15 max.
Chromium	=	0.30 "
Manganese	=	0.20-0.60
Nickel	=	1.5-2.25

S.A.E. Steel 2115 is approximately the same.

The body of the pin is required to be cyanided to 700 V.P.N. with a case depth of 0.035 inch. The end of the pin must be under 300 V.P.N. The pin must bend to an angle of 8 degrees on a 12-inch radius.

Substitution of TOCCO (Induction) Hardened S.A.E. Steel 1045:

It is reported that the U. S. Army is using TOCCO (Induction) hardened S.A.E. 1045 steel pins successfully. By using this method, it is claimed, alloys are saved, production rates are much higher, and there is a saving in labour and floor space. The Marmon Herrington Company is reported to be supplying the U. S. Army.

Road Tests With TOCCO (Induction) Hardened Pins:

Testing was carried out on level ground by the Department of National Defence, with the following results:

One pin failed at 188 miles,

One failed at 214 miles, and

Eight failed at 340 miles.

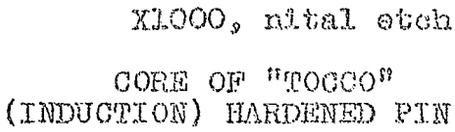
The test was discontinued.

Comparison of Cyanided and TOCCO (Induction) Hardened Pins:

It is reported that after cyaniding the nickel-steel pins were held at 1500° F. and then quenched in water. This would be expected to give a soft, tough core and a hard case.

The case produced on the TOCCO (induction) hardened pins was about 0.100 inch in thickness. Tensile strengths of TOCCO cases on ordinary carbon steel have been reported in excess of 350,000 p.s.i. Of course, this high tensile strength is accompanied by low ductility. The core of the TOCCO (induction) hardened pin was in the annealed, or normalized, condition.

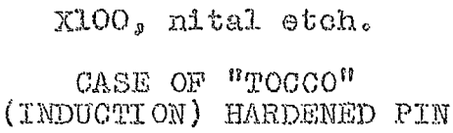
Figure 1.



X1000, nital etch.

CORE OF "TOCCO" (INDUCTION) HARDENED PIN.

Figure 2.



X100, nital etch.

CASE OF "TOCCO" (INDUCTION) HARDENED PIN.

Depth Hardness Relation of TOCCO (Induction) Hardened Pin:

Distance from surface, millimetres.		Vickers Hardness Number, 10-kilogram load
At surface	-	890
0.15	-	695
0.55	-	650
0.90	-	555
1.40	-	525
1.90	-	430
3.10	-	210
7.60	-	205

Bend Tests:

A report from the Cockshutt Plow Company Limited states that cyanided S.A.E. 2115 (0.020-inch case) pins bent in excess of 45 degrees and that TOCCO (induction) hardened pins bent only 8 to 12 degrees in test. The load required to bend the pins 5 degrees was 4,100 pounds for the cyanided pin and 5,600 pounds for the TOCCO (induction) hardened pin.

DISCUSSION:

Service Expected of Pins -

The pins under ideal conditions of service would be subject only to shear stresses, which would be divided among four areas at right angles to the pin. The most severe service expected would be when all of the shear load and some torsion stresses are applied at one area on the pin. A stiff, rigid pin might be stressed four times as

(Discussion, cont'd) -

(Service Expected of Pins, cont'd) -

much as a ductile pin, since the yielding of the ductile pin would distribute the load over several areas. Wear resistance is, of course, essential. The depth of wear-resistant case necessary has been specified as 0.035 inch, although in actual practice it is probable that cyanided cases do not exceed 0.020 inch. The requirements for a tank track pin are:

1. A hard, wear-resistant case.
2. High yield point. This corresponds with a long period of elastic deformation.
3. High elongation and bending angle. This property gives a long period of plastic deformation.

By using test record forms including the following data it will be possible to determine the optimum properties of pins for tank tracks:

Track Pin Test Data.

A. Type of steel: _____
B. Type of heat treatment:
Core _____
Case _____
C. Case hardness: _____ V.H.N.
D. Case depth: _____ inches.
E. Load required to bend 5°: _____ pounds.
F. " " to produce permanent bend of 5°: _____ "
G. " " to bend 10°: _____ "
H. " " to bend 15°: _____ "
I. Minimum bend after fracture: _____°.
J. No. of miles of service in tank track: _____ miles.
K. Type of failure: _____

A standard spacing of 9 inches might be used

(Discussion, cont'd) -

(Service Expected of Pins, cont'd) -

for testing.

If tests are recorded as above and compared with service tests, the ideal physical properties will soon be known.

TOCCO (Induction) Hardened Pin -

The case produced on the S.A.E. 1045 steel pin examined was characteristic of the induction-hardening process. Its wearing properties would compare favourably with either pack-carburized or cyanided low-carbon alloy steel. The extreme depth of the case, however, lowered the ductility of the pin so that all of the load was applied at one area and early failure occurred. Better results would have been obtained if the case had been thinner or softer.

Prior heat treatment of the core is recommended in order to obtain the highest possible yield point without sacrificing ductility. It is recommended that the steel be quenched and drawn to 200-250 Vickers hardness before induction hardening.

Case hardness and depth are functions of the time of heating and the frequency of the power used.

Conclusions:

The TOCCO (induction) hardened pin had a normal structure for induction-hardened carbon steel.

Failure was due to highly concentrated stresses. Ductility, obtained by a long range of elastic and plastic deformation, results in an even distribution of load over four areas in the pin. Rigidity results in highly stressed areas. The TOCCO (induction) hardened pin was too rigid.

By recording data on bend tests as suggested, ideal hardness and toughness properties can soon be determined.

For further tests using TOCCO (induction) hardened pins, it is suggested that the core be quenched and drawn, the case be under 0.050 inch, and the hardness values be reduced.

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