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OTTAWA May 22nd, 1944.

# REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1650.

Metallurgical Examination of Snowmobile Track Reinforcing Cleats.

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(Copy No. 10.)

Bureau of Mines
Division of Metallic
Minerals
-
Physical Metallurgy
Research Laboratories

CANADA

DEPARTMENT
OF
MINES AND RESOURCES

Mines and Geology Branch

OTTAWA May 22nd, 1944.

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### Origin of Material and Object of Investigation:

On May 9th, 1944, Mr. M. H. C. Ford, of the Experimental Engineering Section, Army Engineering Design Branch, Department of Munitions and Supply, submitted, from 433 St. Martin Street, Montreal, Quebec, eight (8) snowmobile track reinforcing cleats. Four of the cleats had failed in service at a low mileage, two had given satisfactory use, and two were unused.

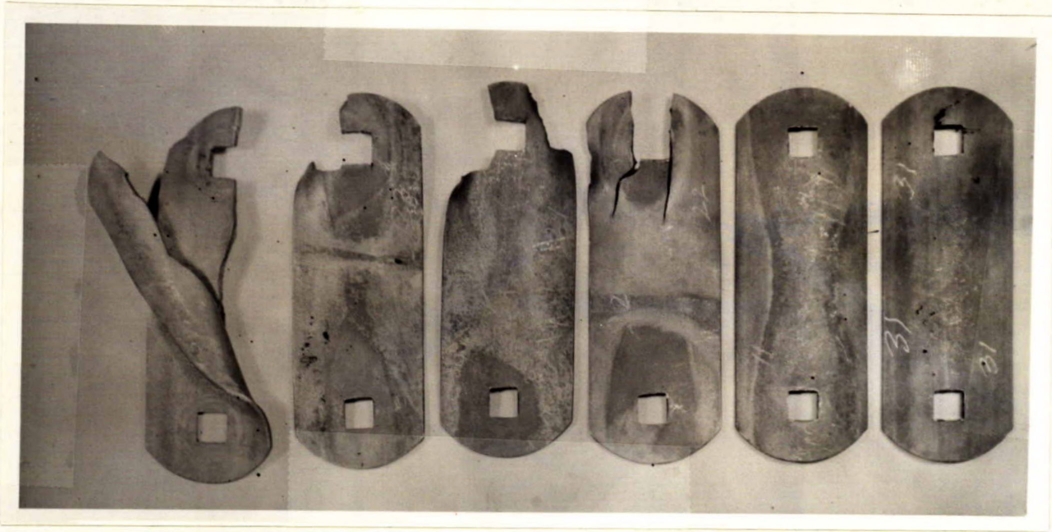
An accompanying letter, dated May 8th, stated that the specification required the cleats to be made from SAE 1060 steel heat-treated to a hardness of Rockwell 'C' 42 ±3. A complete metallurgical examination was requested, to determine the cause of failure.

Macro-Examination:

Figure 1 depicts the four broken and the two unbroken cleats as they were received.

All the cleats were magnafluxed. Examination revealed cracks at the square corners of the bolt holes on the four cleats that failed. These are shown in Figure 2. The other cleats were free of cracks.

Figure 1.



CLEATS AS RECEIVED.

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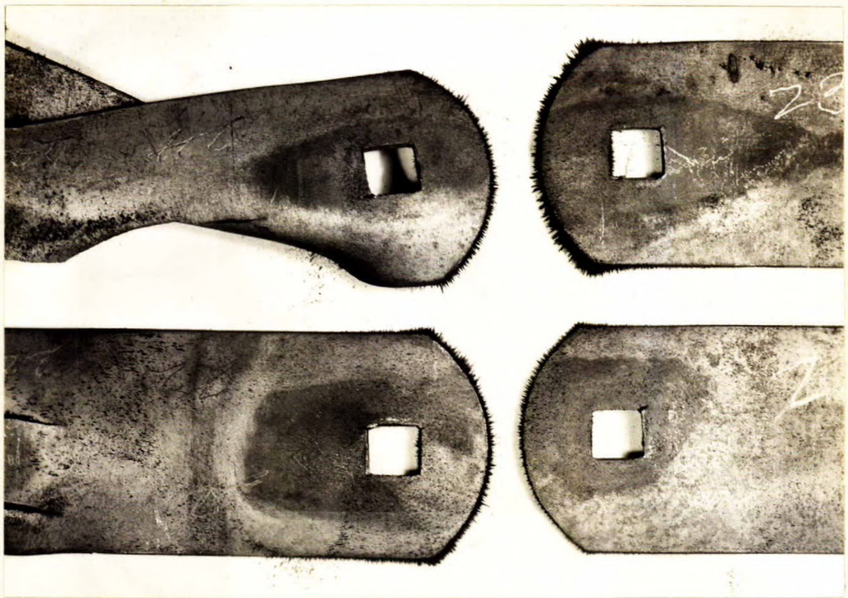
(Continued on next page)

(Macro-Examination, cont'd) -

Figure 2.



MAGNAFLUXED CLEATS.

Note cracks at bolt hole corners.

(Approximately to size).

-

Chemical Analysis:

Drillings were taken, for chemical analysis, from five cleats. The results are listed below:

| | | IDENTIFICATION OF CLEAT | | | | | Specification SAE 1060 |
|---|---|---|---|---|---|---|---|
| | | Used, Unbroken | Used, Broken | Unused | Used, Unbroken | Used, Broken | |
| Carbon | - | 0.41 | 0.60 | 0.55 | 0.50 | 0.57 | 0.55-0.70 |
| Manganese | - | 0.70 | 0.74 | 0.76 | | | 0.60-0.90 |
| Silicon | - | 0.32 | 0.22 | 0.22 | | | 0.15 min. |
| Sulphur | - | 0.039 | 0.043 | 0.046 | | | 0.050 max. |
| Phosphorus | - | 0.021 | 0.012 | 0.012 | | | 0.040 max. |
| Chromium | - | Nil. | Nil. | Nil. | | | |
| Nickel | - | Nil. | Nil. | Nil. | | | |
| Molybdenum | - | Trace. | Trace. | Trace. | | | |

-

Hardness:

The cleats were cut transversely and hardness readings were taken on the cut face, using the Vickers hardness machine and a 10-kilogram load. Vickers readings are shown in Table I, also corresponding Rockwell 'C' figures. The latter were taken from the Scott-Gray conversion chart. The values given are an average of three readings.

TABLE I.

| Pin Identification | | Vickers Hardness Number | Rockwell 'C' converted from Vickers |
|---|---|---|---|
| Used (unbroken) | - | 218 | 17.5 |
| Used (unbroken) | - | 227 | 20.0 |
| Broken | - | 227 | 20.0 |
| Broken | - | 204 | 16.0 |
| Broken | - | 227 | 20.0 |
| Broken | - | 212 | 16.5 |
| Unused | - | 251 | 23.0 |
| Unused | - | 212 | 16.5 |

Grain Size:

McQuaid-Ehn grain size determinations were made on the cleats having 0.41 per cent carbon and 0.60 per cent carbon. Figures 3 and 4, at X100 magnification, illustrate the results obtained, namely:

0.41 per cent carbon = 1-3 grain size.
0.60 " " = 7-8 " "

Figure 3.

X100, nital etch.
0.41 PER CENT CARBON: GRAIN SIZE, 1-3.

-

(Grain Size, cont'd) -

Figure 4.

X100, nital etch.
0.60 PER CENT CARBON: GRAIN SIZE, 7-8.

Microscopic Examination:

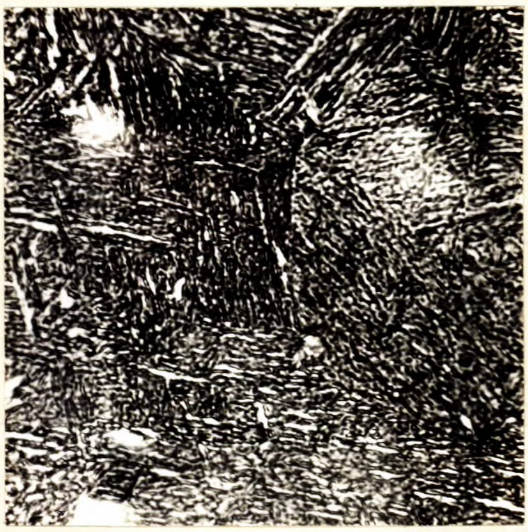
Transverse sections were cut from the cleats and examined under the microscope after having been polished and etched. Figure 5 (X1000) represents the microstructure of the cleats. Figure 6 (X1000) shows the structure obtained by oil quenching and drawing the cleats to Rockwell 'C' 46.

Figure 5.

X1000, nital etch.
ANNEALED STRUCTURE TYPICAL OF ALL THE CLEATS.
Lamellar pearlite and ferrite.

(Microscopic Examination, cont'd) -

Figure 6.



X1000, nital etch.

STRUCTURE OF A QUENCHED-AND-DRAWN CLEAT.

Tempered martensite.

-

Discussion:

The magnaflux examination showed the presence of small cracks at the corners of the unbroken bolt holes of all the broken cleats. The sharp corners may possibly be stress raisers, since all the failures seem to start at these points. To insure against this possibility it may be advisable to increase the radius of the corners.

The chemical analyses indicate that the unbroken cleats have lower carbon contents than those which were broken. Variation in grain size is also observed; the former (0.41 C) has a coarse grain size, 1-3, whereas the latter (0.60 C) is fine-grained, 7-8.

The hardness values obtained for all the cleats examined range from 16 to 23 Rockwell 'C', which is well below

(Discussion, cont'd) -

the 42 ±3 specified. The hardness and the microstructure both indicate that none of the cleats (broken, unbroken, and unused) was quenched and drawn; they all appear to be in the annealed state. It could be expected that if the cleats were heat-treated to the proper hardness by oil-quenching from 1550° F. and drawing, satisfactory service performance would result. If higher hardness, higher tensile strength is required over the present specified 42 ±3, it should be possible to obtain 50 Rockwell 'C', with excellent properties, by austempering a <u>coarse-grained</u> SAE 1060 steel.

<u>Conclusions:</u>

<u>1</u>. On magnafluxing, cracks were observed at the corners of the bolt holes of the broken cleats.

<u>2</u>. The unbroken cleats have lower carbon contents than those which failed .

<u>3</u>. The grain size varies; an unbroken cleat having 0.41 per cent carbon had a coarse grain size, 1-3, whereas a broken cleat having 0.60 per cent carbon had a fine grain size, 7-8.

<u>4</u>. The hardness range of <u>all</u> the cleats was 16-23 Rockwell 'C'.

<u>5</u>. All the cleats appear to be in the annealed condition.

<u>Recommendations:</u>

<u>1</u>. Notwithstanding the carbon content the cleats should be hardened and drawn to the specified hardness.

<u>2</u>. A greater radius at the bolt-hole corners is preferable, although with the cleats heat-treated properly a

(Recommendations, cont'd) -

a change may not be necessary.

3. Higher-strength cleats are possible (if considered necessary) by austempering a coarse-grained SAE 1060 steel.

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SLG:GHB.