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OTTAWA April 3, 1945.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1830.

Metallurgical Examination of Mud Saw Cutting Wheels, Warped in Service.

(Copy No. 10.)

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

CANADA

DEPARTMENT
OF
MINES AND RESOURCES

Mines and Geology Branch

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Origin of Material and Object of Investigation:

On March 8, 1945, four mud saw cutting wheels (see Figure 1), three large and one small, were submitted by the Bureau of Mines, Renfrew, Ontario, for metallurgical examination. The three larger wheels had warped badly in service, whereas the smaller wheel performed satisfactorily. A request was made to determine the cause of warpage.

(Continued on next page)

(Origin of Material and Object of Investigation, cont'd) -

The following wheels were received:

Wheel No.				Diameter, inches		Thickness, inch
1	-	Small wheel, straight	-	7½	x	0.064
2	-	Large wheel, hand peened	-	12	x	0.064
3	-	Large wheel, warped	-	11½	x	0.064
4	-	Large wheel, badly warped	-	12	x	0.064

Figure 1.

MUD SAW CUTTING WHEELS.

(Approximately ¼ size).

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Hardness Tests:

Hardness tests, made in duplicate on samples cut from the four discs, gave the following results:

Wheel No.		HARDNESS Vickers (30-kg. load)	Rockwell "C"
1	-	451-454	45
2	-	520.	51
3	-	575-586	54
4	-	520-527	51

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Chemical Analysis:

The results of the chemical analyses are given in the following table:

		Wheel No. 1	Wheel No. 2	Wheel No. 3	Wheel No. 4
			- Per	Cent -	
Carbon	-	0.96	0.71	0.71	0.74
Manganese	-	0.50	0.31	0.32	0.34
Silicon	-	0.33	0.27	0.28	0.27
Sulphur	-	0.005	0.005	0.005	0.004
Phosphorus	-	0.014	0.014	0.015	0.015
Nickel	-	1.83	2.86	2.86	2.86
Chromium	-	0.63	0.03	0.06	0.03
Molybdenum	-	Trace.	Trace.	Trace.	Trace.
Vanadium	-	Nil.	Nil.	Nil.	Nil.

Microscopic examination:

Microscopic examination of the four wheels revealed a typical tempered martensite structure. Figures 2 and 3, both at X1000 magnification, show the microstructure of Wheels Nos. 1 and 2 respectively.

Discussion:

The hardness tests revealed that Wheel No. 1, which had not warped in service, was from 5 to 9 Rockwell "C" points softer than the remaining three which did undergo warping. Hence, Wheel No. 1 must have been tempered at a higher temperature than the remaining three. This difference in tempering temperature could easily account for the warping, since Wheels Nos. 2, 3 and 4 were not drawn at a sufficiently high temperature to remove all of the locked-up stresses caused by the quenching.

The chemical analyses indicate that Wheel No. 1 is different in composition from the other three, which are practically identical. It is to be noted that Wheel No. 1 is higher in carbon content, lower in nickel, and contains chromium. Because of the higher carbon and chromium contents, Wheel No. 1 probably would have a higher wearing resistance, for the same hardness, than the other wheels. However, it is not thought

(Discussion, cont'd) -

that the difference in chemical composition is directly responsible for the warping. The higher carbon content of Wheel No. 1, however, would mean that a higher draw temperature, with a consequently lower internal stress condition, could be used to achieve the same hardness. The fact that the higher carbon wheel has a lower hardness than the low carbon material would definitely mean that the draw-temperature differential, and consequently the internal stress differential, is even higher than the hardness difference indicated.

Conclusions:

1. Wheel No. 1 has a lower hardness than Wheels Nos. 2, 3 and 4, indicating a higher tempering temperature, which would result in a lower internal stress condition and a consequent greater freedom from warpage in service.

2. The steel in Wheel No. 1 differs from that of Nos. 2, 3 and 4 (which are very similar) in that it has higher contents of carbon and chromium and a lower content of nickel. Only the higher carbon content is considered to have important significance, as it would permit the use of a higher draw temperature for the same hardness (and probably the same wear resistance). This higher draw temperature would result in a consequent lowering of internal stress and probable reduction in warping.

Recommendations:

1. Warping can be minimized by tempering the discs after quenching to a maximum hardness of 45 Rockwell "C", in order to eliminate the internal stresses set up by the quenching operation.

2. The use of the higher carbon material is recommended.

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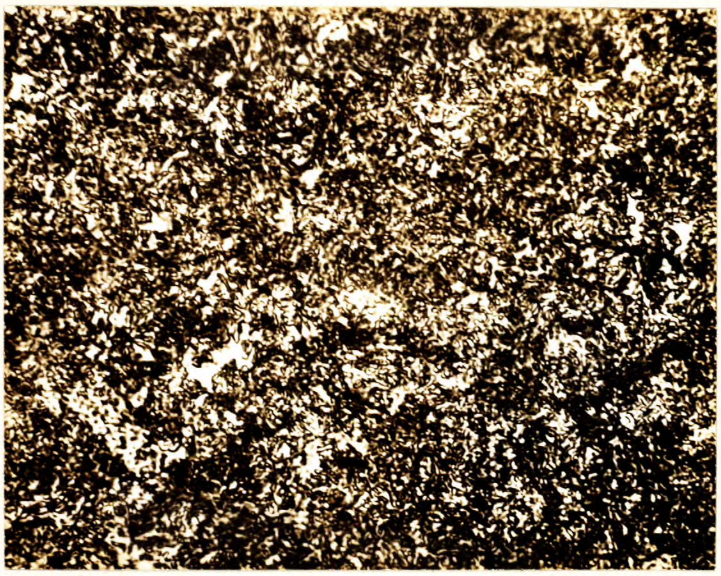
Figure 2.



X1000, nital etch.

SAW WHEEL NO. 1 (STRAIGHT).

Tempered martensite.

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Figure 3.

X1000, nital etch.

SAW WHEEL NO. 2 (WARPED).

Tempered martensite.

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