CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

OTTAWA

MINES BRANCH INVESTIGATION REPORT IR 58-104

EVALUATION OF SNOW PLOW WING SHOES IN 1957-1958 WINTER FOR THE ONTARIO DEPARTMENT OF HIGHWAYS

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PHYSICAL METALLURGY DIVISION

COPY NO. 7

JUNE 18, 1958

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SUMMARY

Snow plow wing shoes made from Ni-Hard alloy cast iron, white iron, chilled nodular iron and austenitic manganese steel were wear-tested in service during the winter of 1957-1958. Many difficulties were encountered which seriously disrupted the project, but general conclusions could still be made. Ni-Hard shoes displayed wearing qualities superior to those of the other materials tested. Shoes of a hollow design were also tested and were found to be satisfactory for use in the Ni-Hard composition.

Recommendations were made to use Ni-Hard snow plow wing shoes of the new design throughout the Province of Ontario. Further comparison tests between Ni-Hard and white iron shoes made to the new design were suggested, provided that there was a substantial price differential between these materials.

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(6 tables, 1 illus.)

INTRODUCTION

In Mines Branch Report of Investigation No. PM3192, dated May 30, 1957, results were reported of a wear testing program carried out for the Ontario Department of Highways on five compositions of snow plow wing shoes. These tests showed the superiority of Ni-Hard alloy cast iron and chilled nodular iron compositions over two low-alloy, heat-treated steels and austenitic manganese steel.

At a meeting held at the Physical Metallurgy Division, Ottawa, in August 1957, with representatives of the Ontario Department of Highways (Messrs. F.C. Brownridge, J. Casey and H. Gilbert), it was decided that in the 1957-58 season the materials to be tested would be Ni-Hard, white iron and chilled nodular iron in the form of conventional solid shoes, plus Ni-Hard and austenitic manganese steel in the redesigned form of a hollow shoe.

TEST PROCEDURE

The only changes made in the procedure as detailed for the previous year were:

1. Ni-Hard was used as a standard.
2. A form was introduced on which the snow plow operators were to record wing mileage rather than truck mileage.

RESULTS

(a) Chemical Composition

The results of chemical analyses of the four different materials, made at the Physical Metallurgy Division, are listed in

Table I. These results are averages of the three heats which were required to produce sufficient shoes of each material. No analyses were made of the solid Ni-Hard shoes, as they were supplied by a commercial foundry and probably represented several heats. That they were Ni-Hard, was confirmed by metallographic examination of polished and etched samples.

Table 1

Analyses of Test Snow Plow Shoes

Element	Ni-Hard (%)	White Iron (%)	Chilled Nodular (%)	Austenitic Manganese (%)
Carbon	3.70	3.37	3.20	1.20
Manganese	0.59	0.65	0.95	13.20
Silicon	0.45	0.42	2.10	0.85
Sulphur	0.026	0.023	0.015	0.012
Phosphorus	0.033	0.037	0.055	0.055
Chromium	2.00	-	-	-
Nickel	4.15	-	-	-
Magnesium	-	-	0.04	-

(b) Hardness

Brinell hardness readings were taken on slices removed from the wear portion of the shoes. These Brinell hardness numbers were taken $\frac{1}{4}$ in., $\frac{1}{2}$ in. and 1 in. below the wear surface. The results of these hardness readings are given in Table 2.

Table 2

Results of Brinell Hardness Tests on the Test Snow Plow Shoes

Shoe Composition	Brinell Hardness Number at Depths of $\frac{1}{4}$ in.	$\frac{1}{2}$ in.	1 in.
Ni-Hard (solid)	541	541	508
Ni-Hard (hollow)	528	528	528
White Iron	436	424	419
Chilled Nodular	444	422	410
Austenitic Manganese Steel (hollow)	188	188	188

(c) Microstructure

Samples from each heat of the compositions made at the Physical Metallurgy Division, Ottawa, were cut from the shoes for metallographic examination. Figure 1, at the end of this report, shows the typical microstructure of the white iron shoes. Typical microstructures of the other materials used were shown in the report of the 1956-1957 tests.

(d) Wear Results

Due to various reasons, which will be discussed later, complete wear data were not obtained for any one period. The usable results obtained are listed below, in Tables 3 and 4.

Table 3

Wear Data for Inner Shoes and Reported Wing Mileage for Certain Tests at Four Stations During Three Periods Covering the 1957-58 Winter

	Snow Plow Station	Aust. Mang. Steel	Chilled Nodular	White Iron	Solid Ni-Hard	Hollow Ni-Hard
		Wear (oz/mile) and mileage (denominator)				
Period A 7/11/57 to 11/1/58	North Gower	0.211 / 1690				
	Carp		0.120 / 2471			
	Vernon			0.074 / 3542		
	Cumberland					0.061 / 2953
Period B 11/1/58 to 28/2/58	North Gower		0.096 / 1492			
	Carp					
	Vernon					0.026 / 2318
	Cumberland			0.037 / 1286		
Period C 28/2/58 to 16/3/58	North Gower					0.017 / 401
	Carp					
	Vernon	0.116 / 556				
	Cumberland				0.032 / 330	

Table 4

Wear Data for Outer Shoes (Solid Ni-Hard)and Reported Wing Mileage for Certain Tests at Four Stations During Three Periods Covering the 1957-58 Winter

Station	Period A		Period B		Period C	
	Wear (oz/mi)	Mileage	Wear (oz/mi)	Mileage	Wear (oz/mi)	Mileage
North Gower	0.118	1690	0.038	1492	0.025	401
Carp	0.020	1695	-	-	-	-
Vernon	0.043	3542	0.019	2318	0.066	556
Cumberland	0.091	2953	0.030	1286	0.049	330

The wear angles were measured on all worn shoes and are reported below, as averages for each station for each of the three periods, in Table 5.

Table 5

Average Wear Angles for Three Periods for all Stations for Inner and Outer Shoes

Station	Average Wear Angle					
	Period A		Period B		Period C	
	Inner Shoes	Outer Shoes	Inner Shoes	Outer Shoes	Inner Shoes	Outer Shoes
North Gower	49.5°	52°	47°	58°	53°	60°
Stittsville	82°	78.5°	-	-	86.5°	86°
Carp	56°	65°	64°	66°	-	75°
Vernon	42.5°	45°	43.5°	46°	44°	41°
Cumberland	54°	50°	52°	58°	53½°	60°

DIFFICULTIES ENCOUNTERED IN WEAR TESTS

As can be seen from the results in Tables 3, 4 and 5, there were only three periods from which wear data were accumulated, and complete data were not obtained from any one period. The reasons for this are numerous. In general, the statistical design used has been found to be too rigid for a field experiment such as was encountered in this project. The large numbers of variables and men involved made it impossible to keep the project adequately under control. Some of the major difficulties involved are given below:

(a) Variable Wear Angles

Table 5 lists the wear angles encountered at the various stations. The wear angle at Stittsville was so steep (around 80°) that the wear data obtained from this station were meaningless and consequently have not been included in Tables 3 and 4.

(b) Broken Odometer

The odometer failed in one truck and the crew neglected to estimate the mileages travelled.

(c) Incorrect Wing Plow

At one station, in the first period, the shoes would not fit the plow. In an unauthorized attempt to fit the shoes, torch cutting was employed. The shoes were embrittled by the heat from the torches, with the result that two shoes were lost and one other cracked.

(d) Failure to Change Over at Correct Time

Through a misunderstanding, four of the five stations neglected to change over from the first period to the second period at the proper time. When this was realized, it was decided to forget the second period, and have all stations change to the third period.

(e) Short Winter Season

As in the previous winter, there was insufficient time to get any test data for the fifth period, since the last date on which the plows were out was March 16, 1958.

BLADE WEAR

Some of the blades from the stations were collected, in an attempt to evaluate the effect of the harder shoes on the wear of the blades. Only blades used with Ni-Hard shoes were received, but, since Ni-Hard was the hardest material, shoes of this type should produce the most pronounced effect on the blade's wearing characteristics. Examination showed that the inner portion wore faster than did the outer. Maximum wear occurred near the inner shoe positions, producing a slightly concave wear pattern. The figures given below are distances measured from the edge of the bolt hole to the worn surface along the length of the blade. The distance was approximately 3 5/8 inches for unworn blades.

Table 6

Measurements Made on Worn Wing Plow Blades Equipped with Ni-Hard Shoes

Approximate Distance from Blade's Inner Edge, inches	Measurement from Bolt Hole to Worn Edge		
	Stittsville inches	North Gower inches	Cumberland inches
3 1/2	1 5/8	3 1/2	1 7/8
19 5/8	1 1/2	3 1/2	1 3/4
35 3/4	1 1/4	3 1/2	1 5/8
51 7/8	1 1/2	3 3/8	1 3/4
68	1 3/4	3 3/8	2 1/8
84 1/8	2 1/4	3 3/8	2 1/2
100 1/4	2 5/8	3 3/8	2 3/4
116 3/8	3 1/8	3 1/8	3
124 1/2	3 1/4		

DISCUSSION OF RESULTS

It is unfortunate that difficulties, once again, made the collected data useful only for general statements in regard to the material best suited to this application. However, it can be stated that austenitic manganese steel is the least suitable, and Ni-Hard the most suitable, of the materials that were tested for wing snow plow shoes in the past two winter seasons.

It is interesting to compare the results for chilled nodular iron shoes and white iron shoes. Both of these materials have close to the same hardness, but the white iron shoes appear to show slightly better service life. The reason for this may be that the chilled nodular iron tends to be less homogeneous in structure than the white iron, due to the fact that the hardness in the nodular iron is obtained by casting against a metal chill, whereas the hardness of the white iron shoes is obtained by compositional control and is quite uniform throughout the section involved.

The more or less linear wear found on the snow plow wing blades examined would tend to dispel the fears that, when very hard shoes were used, the blade might wear excessively in the central portion where no shoes are present. The blades examined had been equipped with the hardest shoes (Ni-Hard) and all showed more wear on the inner side, decreasing gradually to the outer edge of the blade.

Because of difficulties encountered in moulding, white iron shoes made to the new hollow design were not in use until March of this year (1958). Approximately 300 miles were put on the shoes with no trouble from breakage, but a more thorough test would be desirable.

RECOMMENDATIONS

Since the Ni-Hard shoes have shown superiority over the other materials tested, it is recommended that Ni-Hard shoes be purchased for use throughout the Province of Ontario for the 1958-59 winter season. Also, since no difficulty was encountered with the hollow design, it is recommended that this new design be adopted for use with the Ni-Hard composition.

Because the solid white iron shoes showed promising results, the price differential between this composition and Ni-Hard should be investigated; if the differential is great enough, comparison tests between the two materials should be made. The hollow design in white iron should also be tested more thoroughly.

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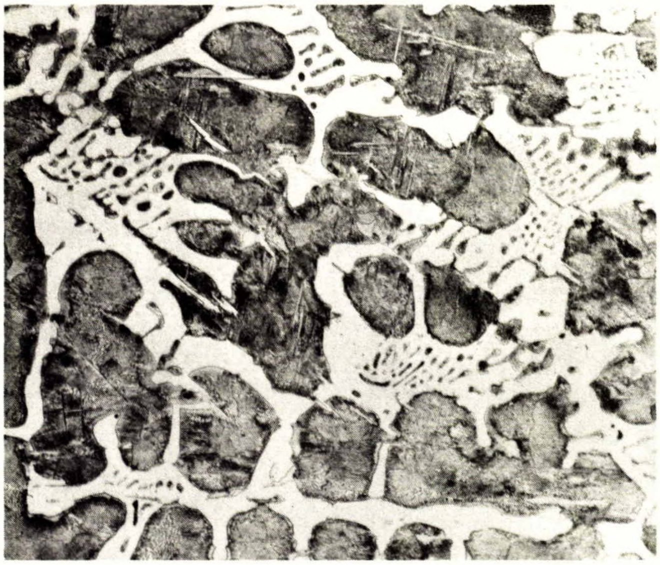
(Figure 1 follows,)
(on page 9.)



(x100, etched in 2% nital)

<u>Fig. 1</u> - Typical microstructure of white iron shoe. The grey material is pearlite, and the white material is cementite.

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