Snow Plow Cutting Edge Cost Effectiveness

Study SD89-04
Final Report

Prepared by
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This report describes research performed by the South Dakota Department of Transportation to determine cost-effectiveness of snow plow cutting edges. Five vehicles at maintenance units around the state were instrumented with mileage counters to record the distance plowed by each set of cutting edges. Two of these vehicles were in Pierre, one in Murdo, one in Presho, and the other in Sisseton. The cutting edges used on each vehicle included a CAT, with and without a 1/2” frontal blade, a Pacal, with and without a 1/2” frontal blade, a Kennametal and a CPL, each with a 1/2”
frontal blade. The results showed the Kennametal blade, which has the second highest cost per foot of the five blades tested, plowed more miles than any of the other types tested, resulting in the lowest cost per mile in each of the five areas.

INTRODUCTION

South Dakota Department of Transportation (SDDOT) uses 418 snow plows to plow over 16,000 lane miles of state highways, investing 40,469 man hours and driving 795,565 miles in 1992. The Department has used carbide inserted and through-hardened cutting edges on their snow removal equipment for the past five years. Kennametal blades cost $24.39 a foot, and Pacal costs $10.91 a foot. Different types of trucks, plows, operators, snow, weather conditions, and highways make determining cost effectiveness of cutting edges difficult. Finding the most cost-effective cutting edge is the objective of this study.

BACKGROUND

The SDDOT, in 1993, has 418 snow plows statewide, and has used various types of blades over the years, often choosing cheaper blades over more expensive ones. In FY 1990, the SDDOT used edges worth $74,535 on carbide inserted edges and $35,380 on through-hardened cutting edges. SDDOT spent $119,950 and $24,700 respectively in FY 1991, $104,760 and $25,490 in FY 1992, and $160,340 and $18,530 in FY 1993. Depending on the winter season, softer cutting edges wear out quickly, forcing the operator to stop plowing snow, deadhead to the shop and change the blade often, sometimes in as little as four hours. The time it takes to change blades ranges from one to two hours, requiring two or three people. Ideally, a set of cutting edges would last an entire winter snow plowing season. This is not possible unless the winter is exceptionally mild. The question is: Would SDDOT achieve a lower cost per mile by using harder cutting edges, or softer edges, which require more time spent to return the plows to the shop, replace the blade, and return to plowing snow? The study began in November, 1988 and was to end in the spring of 1989. Due to mild winters and exceptionally hard cutting edges, the study continued until spring of 1993.
PROJECT DEFINITION

SDDOT Division of Operations is interested in finding which blade would be most cost-effective and practical to use in South Dakota. This project defines the objectives and tasks as follows:

Objective

To determine which type of snow plow cutting edge is most cost-effective for SDDOT.

Tasks

1. Choose five areas that include a diverse selection of pavements and climates.

2. Select and install blades on each of the chosen snow plows, and replace with next test blade as required.

3. Instrument vehicles with sensors and counters to provide measurements of vehicle mileage with the blade in the plow position.

4. Provide operators with instructions and forms to record the required information.

5. Record miles plowed, snow coverage, pavement type and amount of cutting edge wear.

6. Analyze information to determine cost effectiveness of cutting edges.

7. Submit an executive summary summarizing the literature, research methodology, data, findings, conclusions, and recommendations.

8. Present findings and conclusions to SDDOT Research Review Board upon completion of the project.
The Division of Operations chose four blades to be evaluated in this study. The Pacal and CAT blades were each installed with and without 1/2" frontal blades. The blade combinations evaluated and their prices per foot were as follows:

<table>
<thead>
<tr>
<th>Blade Type</th>
<th>1/2 Frontal</th>
<th>Cost/foot ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pacal Case</td>
<td>Yes</td>
<td>17.59</td>
</tr>
<tr>
<td>Pacal Case</td>
<td>No</td>
<td>10.91</td>
</tr>
<tr>
<td>CAT through hardenened</td>
<td>Yes</td>
<td>16.54</td>
</tr>
<tr>
<td>CAT through hardened</td>
<td>No</td>
<td>9.86</td>
</tr>
<tr>
<td>Kennametal Carbide inserted</td>
<td>Yes</td>
<td>24.39</td>
</tr>
<tr>
<td>CPL Carbide inserted and embedded</td>
<td>Yes</td>
<td>47.96</td>
</tr>
</tbody>
</table>

The Pacal and CAT blades installed with the 1/2" frontal blade cost $6.68 per foot more than those without. The blades were chosen for the study because of their durability, cost and availability. These blades have been purchased by the Department in the past and represent those available on the market.

**SITE SELECTION**

The Division of Operations wanted to evaluate the blade combinations under a variety of conditions. Cutting edges were installed on two trucks in Pierre running on asphalt and concrete, one on I-90 at Murdo and one at Sisseton on concrete. Not only are the pavement types different, but the climate, vehicle and operator were unique at each site. Each area used each set of edges. Unfortunately, CPL and Kennametal edges were not tried on one of the Pierre plows because the plows were sold before the end of the study.

**INSTRUMENTATION**

Mileage plowed using each set of cutting edges was measured using a counter designed and built by the SDDOT Office of Research. Because different types of trucks use different types of transmissions and means of measuring their speed, a uniform method of attaching a sensor to the speedometer cable could not be found. The counter uses Microswitch hall effect sensors, Figure 2 on the next page, to detect magnets passing by it as the wheel rim on which they are mounted rotates. Each time a magnet passes by the sensor, a pulse is generated which is counted and divided down to one pulse every 0.1 mile. The counter's display, Figure 3, shows miles travelled by the cutting edges to the nearest tenth of a mile. When the blade is in the carry, or up, position, the counter is disabled, and mileage is not recorded. The sensor that detects whether the blade is up or down is mounted on the plow near the hydraulic cylinder as shown in Figure 1.

**DATA COLLECTION**

Snow plow operators were instructed to record the mileage displayed on the counter on the data collection form at the end of each day of plowing. The operators estimated the percentage of snow and ice that covered the roadway. Other data included were the dates the edges were installed and removed, the beginning and ending counter mileage, and the time and number of people required to replace cutting edges. This data was compiled for each set of cutting edges in each area. Each set of cutting edges was used until it required replacement, when the data collection sheets were sent to the Division of Operations at the SDDOT central office. Some edges lasted longer than one winter season.
Total miles and blade wear were calculated for each set of cutting edges recorded, and cost per mile was in each area. Table 1 below shows the data compiled from each of the five snow plows in the study. Note that on the Pierre units, one plow was sold before the CPL edges could be evaluated and another plow sold before the Kennametal edge could be evaluated. Also, the CPL edge on the Presho unit was used without a frontal blade. The cost per foot of that blade is $41.28. The cost per mile shown reflects this price. Also note that at a few times, the counter on the Presho plow failed to operate. Until the counter was fixed, the operator estimated the number of miles that his blade was in contact with the roadway. The table below indicates when this occurred. Shoes were not used in this study. Although the prices are not the contract price, the cost per foot figures below do reflect the relative costs of the edges.

### Table 1 Snow Plow Cutting Edge Comparison

<table>
<thead>
<tr>
<th>Plow Number</th>
<th>Location</th>
<th>Plow Length/type</th>
<th>Condition Plowed</th>
<th>Edge Height Used</th>
<th>Usable Height</th>
<th>Blade Cost/foot</th>
<th>Miles Plowed</th>
<th>Cost per mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAT Without Frontal Blade</td>
<td>10’ One Way</td>
<td>Asphalt</td>
<td>Covered</td>
<td>3/4”</td>
<td>1.5”</td>
<td>$47.96</td>
<td>620</td>
<td>554</td>
</tr>
<tr>
<td>CAT With 1/2” Frontal Blade</td>
<td>10’ One Way</td>
<td>Asphalt/Concrete</td>
<td>Covered</td>
<td>3/4”</td>
<td>1.5”</td>
<td>$47.96</td>
<td>999</td>
<td>857</td>
</tr>
<tr>
<td>Kennametal with 1/2” Frontal Blade</td>
<td>12’ Rev.</td>
<td>Asph/Conc</td>
<td>Covered</td>
<td>3/4”</td>
<td>1.5”</td>
<td>$47.96</td>
<td>5897</td>
<td>917</td>
</tr>
<tr>
<td>CPL with 1/2” Frontal Blade</td>
<td>12’ Rev.</td>
<td>Asph/Conc</td>
<td>Covered</td>
<td>3/4”</td>
<td>1.5”</td>
<td>$47.96</td>
<td>5897</td>
<td>917</td>
</tr>
<tr>
<td>CAT Without Frontal Blade</td>
<td>10’ One Way</td>
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<td>Covered</td>
<td>3/4”</td>
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<td>CAT With 1/2” Frontal Blade</td>
<td>10’ One Way</td>
<td>Asphalt/Concrete</td>
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<td>5897</td>
<td>917</td>
</tr>
</tbody>
</table>

- **Width**: 3/4”
- **Cost/mile based on $41.28 price w/o frontal blade.**
As stated previously, performance of cutting edges is based in this study on the number of miles a particular set of edges has plowed. The time, personnel and materials required for replacement of cutting edges are identical for each kind of edge.

To determine usefulness, the initial height of the cutting edge was divided by the amount of the edge used and multiplied by the miles plowed. This results in the mileage that would have been plowed, had the entire height of the blade been used, based on how many miles were actually plowed by the cutting edge used. The data was compiled using a spreadsheet and is shown in Table 1 on the previous page.

The number of miles plowed by each set of cutting edges on each vehicle varied widely. By looking at the charts that follow, however, one may see some very definite patterns develop. In comparing the miles plowed by each area on each blade, one may see that Murdo and Presho are consistently lower than the others. Possibilities may be type of pavement, higher plowing speed on the interstate, pressure on the blade, or other techniques used by the operator. The ratio of miles plowed by each area is consistent for each cutting edge (Figure 4). Percentages are higher for cutting edges in Pierre where one cutting edge is missing because it was sold before completion of the study.

The number of miles plowed using the Kennametal edges is consistently higher than that of the others for each area (Figure 5). The cost per mile for Kennametal edges is the lowest of all the cutting edges evaluated in each area (Figure 6). According to the percentages of snow, ice and dry pavement recorded in the data, cutting edges were exposed to similar conditions. In an analysis of the data, location was a significant factor. This was evident in Murdo and Presho, where miles plowed was less than other areas, although the reason for it is not clear. The snow cover was not always in favor of the Kennametal edges, yet they still plowed more miles.
The next most significant factor was the type of blade. This verified that the edges are significantly different, and that Kennametal edges are more cost-effective as shown in Figure 6 below.

Figure 5 shows the mileage plowed by each set of cutting edges in each area. Kennametal and CPL edges plowed the most miles by far. Even in Murdo and Presho, which got far fewer miles out of their edges compared with the other areas, the Kennametal and CPL outperformed the others. Figure 6 below shows the cost per mile for each edge including labor costs for replacing edges. The Kennametal and CPL blades achieved the lowest costs per mile. Kennametal edges cost even less per mile than CPL, even in Presho where CPL edges plowed slightly more miles. Labor costs were estimated by using $8.00 per hour plus 40% benefits for a highway maintenance worker working two hours divided by the number of miles plowed.

OBSERVATIONS

Except for Murdo, the cost per mile for each area is higher for a CAT with a frontal blade than one without a frontal blade.

Except for one Pierre plow, the cost per mile for each area is higher for a Pacal without a frontal blade than a Pacal with a frontal. The Pacal with a frontal plowed more miles than the edge without a frontal, therefore offsetting the cost of the frontal blade.

Except for Presho, the number of miles plowed by CAT and Pacal edges with frontal blades is higher in each area than those without.

Kennametal had the lowest cost per mile in each area, and, except for Presho, plowed more miles than other blades in each area.

All five types of cutting edges require approximately the same amount of time, number of bolts and people to install/replace - about two man-hours per set of cutting edges.

Murdo and Presho plowed fewer miles on each set of cutting edges than the other areas. The reason for this is not known.

Snow plow operators observed that using a frontal blade causes the thicker blade combination to "float" over the surface, leaving excess snow on the ground. In the operator's opinion, a single blade without a frontal blade seems to cut snow and ice more efficiently, although is more prone to shock and chipping.

Operators prefer the Kennametal blades over the others because the blades last longer and require fewer returns to the shop for replacement. Much valuable plowing time is wasted while the operator is in the shop during a snow storm replacing cutting edges.

SUMMARY AND CONCLUSIONS

The cutting edges used in this study were representative of those on the market. The Kennametal carbide inserted edges showed the lowest cost per mile of any of the edges tested. Many areas are already using Kennametal edges because the operators have realized more plowing time and fewer return trips to the shop and less down time necessary for replacing edges.

By using carbide inserted cutting edges rather than Pacal edges, as shown in Figure 7 as the lowest and highest cost per mile respectively, SDDOT could save 53¢ per mile, or $421,650 over the...

**RECOMMENDATION**

Because carbide inserted cutting edges achieved the lowest cost per mile of the edges tested in this study over a variety of conditions, the researcher recommends the SDDOT Division of Operations purchase Kennametal or similar carbide inserted cutting edges for snow and ice removal operations until a more cost-effective edge becomes available.
Figure 8 shows the schematic for the counter. With a few exceptions, parts used were all readily available from the local Radio Shack. The Hall effect position sensors were manufactured by Honeywell Microswitch (Figure 2). The 12 Volt electromechanical counter used was manufactured by Durant Manufacturing Company. The counter and display were mounted in the cab of the snow plow mounted in or under the dash. Figure 3 shows these components.

### COUNTER CIRCUIT

The Microswitch hall effect position sensor produces a pulse every time one of the five magnets mounted to the wheel rim passes the sensor as the wheel turns. The input from the sensor enters the 74C221 one-shot that outputs a short pulse on the falling edge of the signal. The output of the one-shot enters the clock input of the first of three cascaded divide-by-N binary programmable down counters. Each down counter, a 4526, has four data lines which may be set using a dipswitch. The counters will count down from the number set by the dipswitch to zero, at which time the output from the last of the three 4526's goes high. This output is hardwired to the 74C221, which in turn outputs a short pulse to a LM395 output transistor, whose output advances the mechanical display one count. The counter will count pulses from the sensor unless the inhibit signal is high. Inhibit will be high whenever the blade is up and the sensor on the vehicle no longer senses the presence of the magnet on the blade.

### CALIBRATION AND RESOLUTION

The counter is calibrated by setting the dipswitch to binary 0001 and driving the vehicle a known distance. The number displayed on the counter must then be converted to miles, and then to binary. For example, the counter will display "500" after driving 1000'. There are 5280' in a mile, so multiply 500 by 5.28 to get 2640. This number must then be converted to binary and then set on the dipswitch. The switch would be set to 1010 0101 0000.

The snowplows used wheels with an inside diameter of 20". Five magnets spaced equally inside the rim were 12.6" apart, which is the resolution of the counter. Using the counter to measure 5000 miles would yield an error of less than a mile.