Engineering Studies for Snow Removal

E. C. Bain

Changes in snow-removal methods will occur when snow removal is fully recognized as an engineering problem and sufficient engineering studies are made. Because adequate information and data are not available, the design and manufacture of snow-removal equipment has changed very little since the 1930's. Some of the needed engineering studies discussed in this paper are (a) advantages of snow-throwing over snowplowing, especially in preventing snowbanks or snow traps from accumulating along highways; (b) relationships among design of equipment, speed of vehicle, amount of snow, and distances snow can be thrown; and (c) safety features required on snow-throwing equipment operated in the 20 to 30 mph range.

In the 1920's I lived in a rural district in a heavy snowfall area in eastern Canada where our Model T Ford had to be put up on blocks from December to April because of snow-blocked roads. Then we had to wait another month in the spring after the snow had gone for the roads to dry up. This, as you may appreciate, created great hardships on a boy then in his teens. Perhaps those hardships led to my continued interest in the snow-removal problem. In many areas snow removal did not start until the late 1920's and early 1930's. Following my graduation with an engineering degree, I furthered my studies of machine design and found myself during the war, from 1940-45, responsible for snow removal and winter maintenance for the Royal Canadian Air Force on airports across Canada and Newfoundland. During this period I made many visits to the United States as aviation engineers had a very close working arrangement.

Following the war I stayed in the snow-removal field and became manager of Walter Motor Trucks of Canada. It became apparent to me at an early date that while truck design had advanced rapidly, particularly with the high-horsepower engines that were becoming available, attachments for large trucks were changing very little except for the V-plow. Therefore, in 1954 I started experimenting and began designing attachments for high-horsepower trucks. I have been most pleased with the results and can report we now have 4 entirely different attachments for these trucks that have proved most successful.

The reason for this resume is to indicate that over the past 40 years many of these gray hairs I have accumulated can partly be attributed to snow-removal problems. During these years I have attended many snow-removal symposiums, and I was always somewhat amazed and annoyed that the snow-removal problem never seemed to be approached from an engineering standpoint. In fact, I was beginning to believe that no one shared my opinion until I heard David Minsk give a paper to the AAAE International Aviation Snow Symposium in 1967 in which he stated: "For one thing, no engineering study has been made in the United States of the material being handled to provide a sound basis for equipment development." I have rechecked recently with Mr. Minsk, and he confirms that this is equally true today in the United States, and I know it is for Canada because I have just completed an examination of material in technical libraries, including the National Research Council library.

In an age of such colossal engineering achievement, it is astonishing that more engineering information on snow methods and techniques is not available. This whole problem becomes more ridiculous when we consider that we can get a man to the moon and back, yet we cannot get him from one town to the next after a moderate snowstorm—no wonder we often have a state of emergency declared.

ENGINEERING STUDIES FOR SNOW REMOVAL

Because engineering data are not available, the design of a great deal of snow-removal equipment has changed very little since the 1930's, even though high-horsepower, high-torque engines are now available for trucks. I feel very strongly that adequate engineering studies would show many things in terms of economic factors, new techniques and methods, and more correct selection of horsepower requirements; needless to say, they would bring advancement in the design of snow-removal equipment. In this paper I am confining my remarks mainly to roads, highways, and airport areas where it is possible to use high-speed snow-removal equipment.

Snowbanks and Snow Traps

Our most serious and costly problem is snowbanks or snow traps along roads and highways. This problem has been most successfully attacked by highway planners, designers, and construction engineers. They have done a tremendous design job and eliminated many snow traps, but much is still needed from the mechanical standpoint. It was recognized at an early date that snowbanks and snow traps can accumulate great tonnages of snow, particularly when there are snowdrifting conditions. For example, 1 ft of snowbank can trap 1,000 tons of snow per mile, and 10 ft of snowbank can trap 10,000 tons of snow per mile. These large tonnages take enormous effort to remove no matter what type of equipment is used. Therefore, some method of mechanical means must be used by the maintenance engineer to prevent these snowbanks from building up. Slow-moving equipment that pushes or plows snow to the side of the road in an area where speed can be maintained could be the worst action. In fact, the V-plow is the most efficient attachment for the opening of snow-blocked roads, while at the same time it can be classed as the most effective piece of equipment yet devised for the building of snowbanks when operated at slow speed.

Classification of Snow Removal Methods

Every piece of snow-removal equipment should be valued and classified for the type of work it is expected to do. A suggested division is as follows:

No.	Type of Work	Type of Equipment
1	Snow-dozing	Very slow-moving equipment
2	Snowplowing	Slow-moving equipment
3	Snow-throwing	Fast-moving equipment
4	Snowblowing	Rotaries of various types

There appears to be the greatest confusion between snowplowing and snow-throwing equipment. In fact, too little is known about the snow-throwing possibilities. I was very pleased to hear that this is receiving some attention in Japan.

At slow speeds snow is pushed or plowed, but at the faster speeds of 20 to 30 mph it is thrown. With high-horsepower, high-torque trucks, it can be thrown in very large tonnages. Properly designed snow-throwing equipment powered with large engines has been used most successfully for years by the railroads. Any railway engineer will tell you that they never plow snow but that they operate at 30 to 35 mph speeds and throw snow in large tonnages. They have always used momentum and high-horsepower engines.

To substantiate my opinions and observations I find it necessary to present data on attachments that we have compiled for high-horsepower, high-torque powered trucks, because other information does not appear to be available in any technical library. In presenting my data, my chief concern is that it not be interpreted as a sales talk. I can assure you that the data used were compiled by a government source, and I was not aware of the results until many months after they were collected.

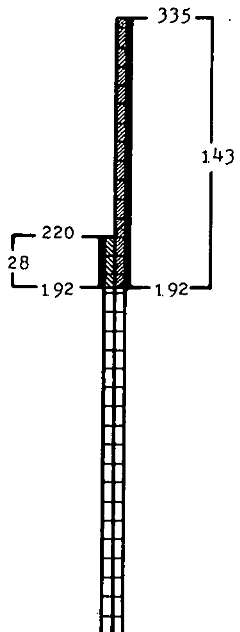
The question may be asked, What is new in the information we have collected compared to the snow-throwing methods we have used for years? I agree that for very light snow the snow-throwing method has been used very successfully, but for moderate or heavy snow in most cases it has not. The reason is that there is not sufficient power and torque available in most truck engines to maintain snow-throwing speeds of 20 to 30 mph. From 1930 through 1950, engines of sufficient size were not available, but that is not the case in the 1960's. During the period when snow-removal demands increased, the trend was to increase the number of units rather than to get more efficient units.

Figure 1 shows the comparison between 2 identically equipped trucks, one powered with a 220-hp engine and the other with a 335-hp engine. This figure gives some idea of the snow-throwing capacity of each unit in the 20 to 30 mph speed range. The truck with the 335-hp engine has 410 percent more horsepower available than the 220-hp truck.

If we accept the accuracy of these figures, then how can it be possible to throw snow in large tonnages with low-torque engines? Most gasoline engines used in snowplow trucks have between 350 and 500 ft-lb of torque at 2,800 rpm. Compare this to the 220-hp diesel with 606 ft-lb at 1,600 rpm. Even with the 220-hp diesel, the 28 hp available for snow-throwing is about the same as we now find in a modern snowmobile. The difference in price of the engine in a truck powered with the 220 or 335 hp is less than $1,000; therefore cost is not the deciding factor.

Figure 2 shows that tonnage up to 261 tons/min was thrown at a distance of up to 45 ft at 32 mph when a 300-hp, 700 ft-lb torque engine was used in a truck with a new design in snow-throwing attachments. In the second test, 266 tons/min was thrown 29 ft at 22 mph.

In both tests it was indicated that sufficient horsepower was still not available, because the deciding point should have been where the snow-thrower pushes sideways out of the snow and this point was never reached. It was calculated that, to maintain 25 mph, over 400 hp would be required. Such engines have recently become more popular, and the possibilities in this field are tremendous. However, very careful consideration has to be given to snow-throwing attachment design, particularly one that will give a



Item	220 hp 606 ft-lb Torque 1,600 rpm	335 hp 865 ft-lb Torque 1,400 rpm
Accessories and hydraulic losses	-32	-32
Drive-line losses	-40	-40
Rolling resistance 40,000 GVW at 25 mph	-53	-53
Cutting-edge resistance	-67	-67
Total losses	-192	-192
Available net horsepower at 25 mph for throwing snow		
on 0 deg grade	28	143
on 2 deg grade	0	90

Figure 1. Comparison of 2 identically equipped trucks with 335- and 220-hp engines.

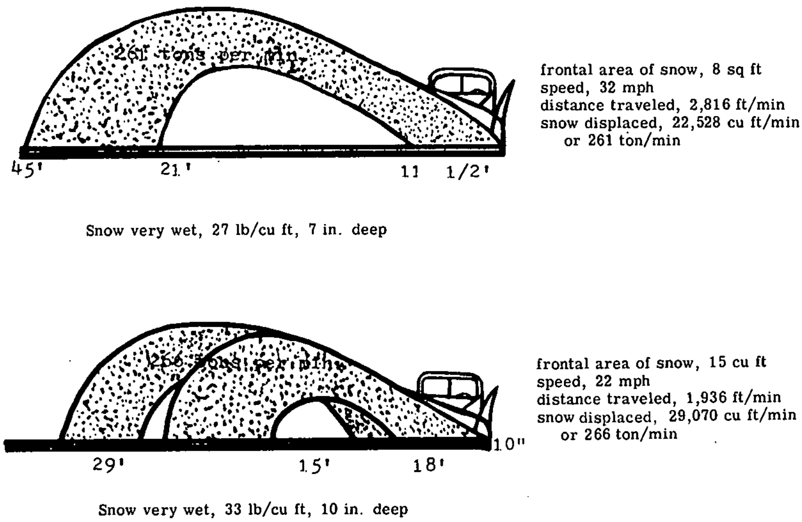


Figure 2. Snow-throwing in large amounts (extra tonnages due to advantage of right moldboard).

wider swath, such as wing or side moldboards. They must be fitted with safety features that enable rapid folding. With properly designed snow-throwing attachments on high-horsepower, high-torque trucks there would be greater efficiency, more roads open, and better service to the public.

Economics

From the standpoint of economics, I believe the amount saved would be in the millions. An analogy can be made between snow equipment and airport crash trucks because both are emergency equipment. The users of crash trucks have recognized that it takes 3 men per 8-hour shift or 9 men for 24 hours and 3 extra men to cover the 40-hour week, a total crew of 12 to man 1,000 gallons. The same number is required to man a 3,000-gal unit. Therefore, when a 3,000-gal unit was used instead of three 1,000-gal units, savings (based on $10,000 per man and two 12-man crews) amounted to $240,000 per year. Over a 10-year period, this would be $2,400,000. Although the savings would not be as great with snow-removal equipment, which is used seasonally, the savings would also be colossal. Only accurate and sufficient engineering studies will indicate the course we are to follow in the future and will bring about the necessary changes in design. In fact, our present design, shapes, and angle of blades may prove to be as obsolete as the 1930 automobile.

SNOWBLOWERS AND ROTARIES

Snowblowers or rotaries do very well the job for which they were designed. They can load snow and throw snow greater distances than snow-throwing truck attachments. Unfortunately, their tonnage range is from 0 to 35 tons/min. When great distance of throw is not required, properly designed snow-throwing attachments can throw up to 260 tons/min, nearly 10 times as much. As indicated earlier there are many areas where this snow-throwing technique cannot be practiced and snow ridges or banks will be built up. Therefore, for these conditions other methods should be used to cut down and remove these snowbanks.

Safety Attachments

Safety may be one of the chief reasons why the snow-throwing method in the 20 to 30 mph range has never been fully developed. Trucks should be fitted with a safety speed wing that folds instantaneously when operated in traffic or when obstructions are encountered. Speed wings or side moldboards should be designed from the standpoint of shape, contour, and angle (a) to throw snow safely in the 20-30 mph speed range; (b) to throw snow at this speed without the chassis being swung around or off the road when obstructions are encountered; (c) to fold instantaneously should the operator need to get around obstructions; and (d) to make it unnecessary for the operator to pull out into the oncoming traffic lane when passing parked or stalled vehicles because the operator can push the control handle and the wing or moldboard will fold in.

Informal Discussion

D. L. Richardson

Do you have any complaints from your citizens when the snow winds up on their front porches?

Bain

We have quite a few of them. In one province we have to issue special instructions to move cars back 25 ft because the first time we drove into 2 cars. That did not help too much politically.

P. A. Schaerer

I am surprised to hear that some areas of the country are so backward in snow removal, and I do not want our friends from overseas to go back home with the wrong impression. I would just like to say it is not so in the west of this continent. From my knowledge of the roads in British Columbia, snowblowers are gradually being pushed out of work because plows are more powerful and can throw the snow to the side. There are plows available that plow uphill on 6 percent grades at 30 or 40 mph.

Bain

That is right. They use turbine engines. We are talking about using engines in the 350-hp range, such as Cummins 335 and GM 871. We are building a unit now with a V-12 engine, which will have 450 hp. In British Columbia, they have recognized that because of the grades they will have to go to a turbine engine to get the horsepower although it is not too economical on fuel. We are going to stick to diesels for a while yet.

David Minsk

The science of snow mechanics began in 1936, probably, at the Swiss Federal Institute for Snow and Avalanche Research. Unfortunately the work was printed in German and required the ability to read and interpret. That was not done on this continent for some time. There is an immense amount of material available on the science of snow mechanics and the properties of snow, but the engineering application of this information has not been done to any great extent. And that is the point I made, and it should be interpreted as such. Many of the tests that have been run in this country and elsewhere should have been reported in the Journal of Irreproducible Results because they did not take into consideration the properties of the material. It is available in Canada at the National Research Council, an organization with which we have very close working relations. What is required by the individual interested is the ability to read and interpret what is available to make engineering applications.

Richardson

The plow you showed plowed at one angle then reversed to another angle for use as a V-plow. Have you had much truck damage from hitting an obstruction while plowing at that speed?

Bain

That plow was built for a special use in an area where we had terrific drifing. We would go up with a one-way plow for about a mile and then strike a drift area. We could then swing the plow to a V and came back through it. We could also directionalize snow. In other words, if the snowbank was filling up on one side, we could use the plow as a dozer to doze it down. A big problem is to get the operators to use it as it is supposed to be used because some are used to the old V-plow and some are used to the one-way plow. I am not saying that this is the ultimate answer. I am saying that engineering studies will bring about, I think, quick changes in all types of equipment.