

# STUDY ON THE DEVELOPMENT OF MULTIPURPOSE SNOW REMOVAL VEHICLES

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## ABSTRACT

This study is to develop an equipment which enable to integrate with a dump truck, collect and dissolve snow cover on the road. Our studies is performed in order to develop vehicles that meet three kinds of research purpose. The first one is to perform the feasibility of development by using effectiveness analysis. The second is a multi-purpose snow removal equipment capabilities and Utilization Analysis. Last study analyzed Multi-purpose snow removal equipment and related technologies. Through this study, two were designed in order to develop a multipurpose snow removal vehicles suitable for Korean terrain and climate characteristics. Lingering snow roads become the problems of the existing snowmaking operations was designed to enable the collection and rapid removal. Design concept for the development of a vehicle with the versatility considering the routine road management practices other than winter.

## 1. INTRODUCTION

By harsh cold and frequent heavy snow of winter due to abnormal climate changes occurring around the world, weather related road accidents are continuously increasing. In particular, unexpected heavy snow paralyzes city function temporarily, which causes enormous economic and social damages and raises road traffic management and safety concerns

In this study, we conducted a study to develop all season multi-purpose vehicles which can melt snow immediately after collecting in the field to make prompt snow removal work to be done for maintaining smooth traffic flow and run daily road maintenance functions in off-winter seasons. Accordingly, we proposed a snow melter used for a snow removal equipment that can deal effectively with heavy snow and extreme cold, and identified and analyzed road maintenance work of off-winter seasons to develop a vehicle available year round. Based on the above information we also derived concept design and required functions for a multi-purpose snow removal vehicle



Figure 1 - Paralyzed transportation function by heavy snow

## 2. PURPOSE OF STUDY

Recently in the downtown area of South Korea, remaining snow along the road still takes over sidewalks and part of driveway after snow removal work and frozen snow melts during the day, and then freezes again at night, causing traffic accidents. Further, snow not yet cleaned up during snow removal work begins to pile up in the middle of the road to form knee-high ice which, together with slippery roads, threatens the safety of vehicles and interferes with smooth traffic flow. However, although winter period in Korea is relatively short and damage due to heavy snow is continuously increasing, vehicles only available for snow removal are falling behind in the priorities of development for the economic aspect.

Therefore, the purpose of this study is to develop a multi-purpose snow removal vehicle which can solve the problems of remaining snow by directly melting and processing snow during heavy snow and at the same time perform common road maintenance work.

### 3. INTERNATIONAL AND DOMESTIC TECHNOLOGY TRENDS

A snow melter, which has been developed by Metro Roads and Works Department (currently, Toronto Transportation Services) of Canada in 1974, is one of snow removal equipments to be used for snow removal work in a large open space or runway. It can discharge snow piled up on the road into sewers by quickly melting and is useful when there still remains a lot of remaining snow on the road due to short term heavy snow showers followed by sustained low temperatures.

Snow melter manufacturers, who are in charge of North America, include Trecon Combustion Limited of Canada, Snow Removal Systems, Inc, Michigan Melters and Snow Dragon Snowmelter of US. Their equipments are all used to immediately melt snow collected mainly from airports. Particularly in Snow Removal Systems, Inc of US, R&D research on the development of mobile/vehicle detachable snow melters is in progress. In Russia, because historically there has been much snowfall, snow melters and equipments for collecting snow piled up on the road are frequently being used.



Figure 2 - Snow removal equipments for collecting snow along the road

In Korea, a snow melter was developed for the second time in the world after Canada, The equipment is designed to discharge meltwater through a tube when the volume of the storage tank reaches overflow level after heating water using a burner installed in a storage tank of a stationary snow melter and scattering hot water by an air blower to melt snow



Figure 3 - A snow melter

### 4. ANALYSIS OF ROAD MAINTENANCE PROCESSES FOR THE DEVELOPMENT OF YEAR ROUND USABLE MULTI-PURPOSE VEHICLES

In order to analyze the function formulation and specification design of multi-purpose snow removal vehicles, we analyzed annual road maintenance processes including snow removal work carried out in one of road maintenance organizations of Korea (Table1).

As the classification above was obtained by investigating the annual road maintenance processes which were commonly performed in domestic road maintenance organizations, we also investigated the required time (start and end points) for each process and the type of equipments used.

The type of equipments to be inputted to each road maintenance process was proven to be very diverse. Figure 4 shows the type of equipments used for domestic snow removal work and Figure 5 presents the type of equipments used for road maintenance work in off-winter seasons. Through this, it was verified that the equipments to be inputted to only snow removal work of winter are more diverse than other equipments to be put to multiple tasks in off-winter seasons, implying snow removal work of winter accounts for an important part of road maintenance work.

With the exception of snow removal work of winter, the most important work in annual road maintenance processes is "cleaning work", and this cleaning work is subdivided into various types of roads, bridges, tunnels and facilities cleaning. The reason "cleaning" is regarded as a major work is because a large amount of garbage is piled up on the roadside (in particular, road shoulders and drain holes) by the passage of vehicles and throwing, which serves as a great difficulty in snow removal work in winter and flood preparation in summer

In conclusion, there exist differences by region and road characteristics in human resources, equipments and period inputted to the processes. However, it can be summarized that the work which in general accounts for the highest percentage in working period of annual road maintenance processes is snow removal work in winter and cleaning work in off-winter seasons.

Table 1. Annual road maintenance processes

Common road maintenance work		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
road maintenance in winter	snow removal	—————										—————	
	snow removal work preparation										—————		
	snow removal material obtained			—————					—————				
Roads/facilities cleaning				—————					—————				
Weeding						—————			—————				
Drainage cleaning						—————							
Flood preparation							—————						
Pavement repair				—————									
Patrol, safety facilities inspection, fallen objects collection garbage collection, etc.		Performed yearly at any time											



Figure 4 - Type of equipments used for domestic snow removal work





Figure 5 - Type of equipments used for road maintenance work in off-winter seasons

## 5. FUNCTIONS AND UTILIZATION OF MULTI-PURPOSE SNOW REMOVAL VEHICLES

### 5.1. Concept design of multi-purpose snow removal vehicles

The processes performed in this study for the concept design of multi-purpose snow removal equipments were schematically represented in Figure 6 in which the required functions of the equipment to be developed were analyzed. The functional analysis was decomposed into several steps from the functions of an abstract step to the functions of a specific step, using the functional decomposition method of Fadel and Kirshman, which is one of the design techniques of existing machinery products. In the next step, components were selected according to the decomposed functions, during which the components which satisfied most the conditions of a given function were selected. For example, a melting method and a melting furnace which satisfied the function of melting snow with the most realistic and favourable conditions were selected.

After selecting the required components for functional satisfaction, the actual running states of components using an engineering analytical method (step 3 in Figure 6) were analyzed. During this process, calories in a melting furnace, transport capacity and power consumption of a blower as a snow transporter were also calculated. Finally, through the layout analysis with configured components to be mounted on the vehicle, the size and appropriated position of each component were selected.

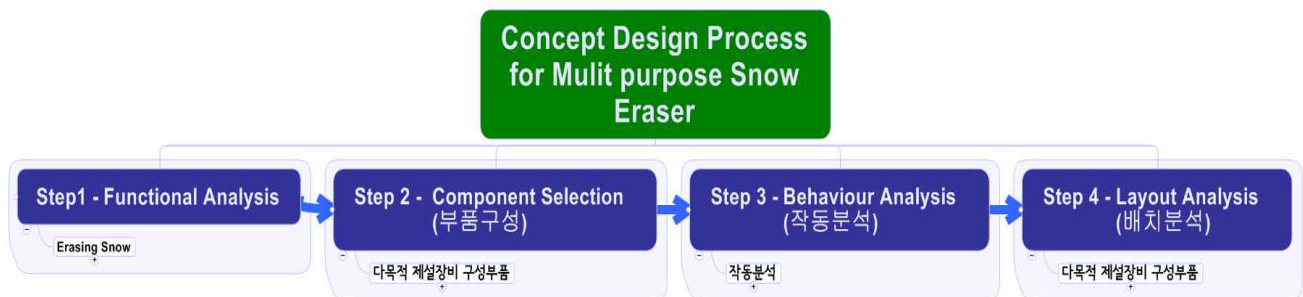


Figure 6 - Concept design processes of a snow transporter

### 5.2. A vehicle usable for daily road work in off-winter seasons

#### (1) Unit equipment for multi purpose

A unit equipment can be classified into two major types. One of them is a unit equipment mounted on the front and the other is a unit equipment attached to a stacker. On the front part, snow removal blades, brushes for removing remaining snow, ice crushers, guard rail cleaners, and mowers, etc can be mounted, and in a stacker, tunnel cleaners and sprinklers can be included(Figure 7). A sprinkler that is attached to a stacker can be efficiently utilized, as shown in Figure 8, by securing more capacity than in conventional sprinklers to increase available working space.

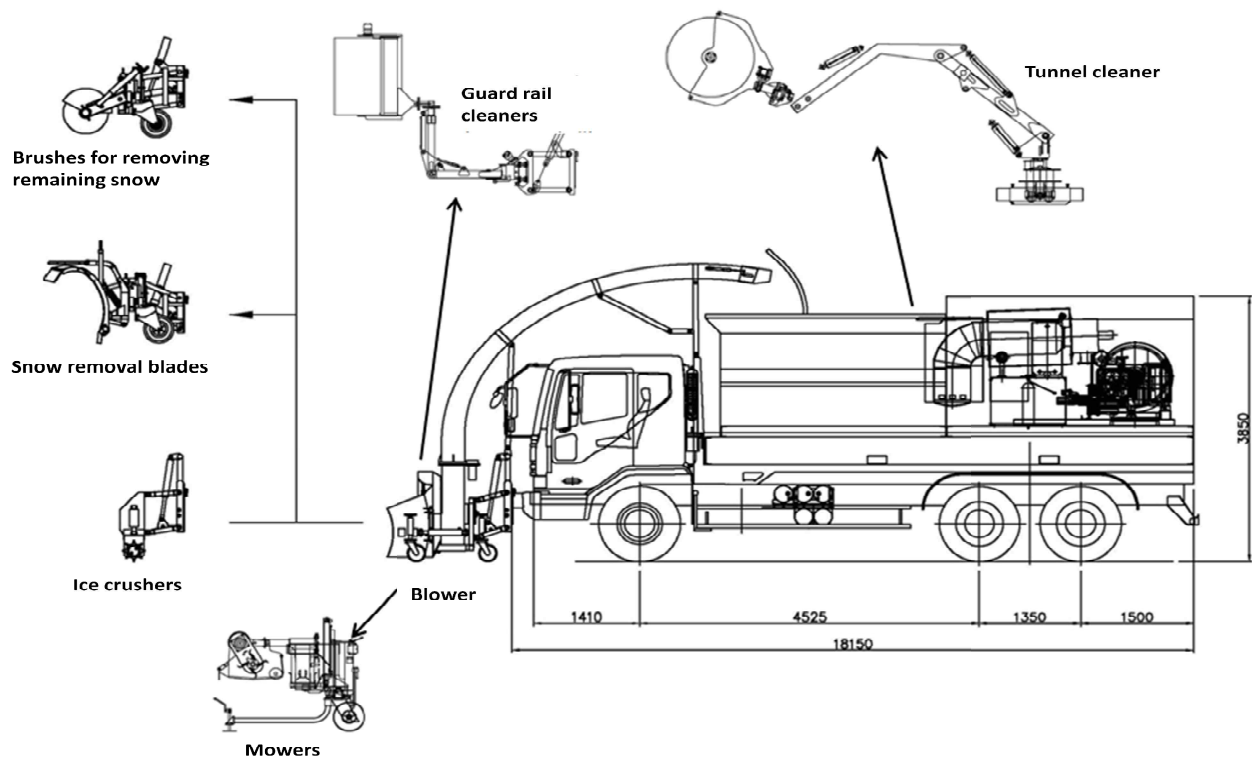


Figure 7 - Concept of a unit equipment

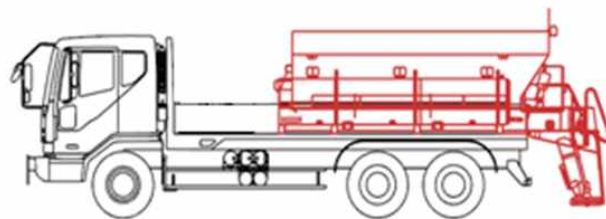


Figure 8 - A stacker mounted unit equipment

## (2) Sprinkling functions through detachable melters

All unit equipments with detachable melters can be used as a snow removal vehicle in winter as shown in Figure 9. With sprinkler equipments attached, they also can be utilized in cleaning work in off-winter seasons. Also, a meltwater storage tank in a stacker can be used as a secondary water tank vehicle in off-winter seasons when fixed. Accordingly, melting furnaces, burner assembly and meltwater storage tanks can be detachable from the equipments to mount sprinkling tanks.

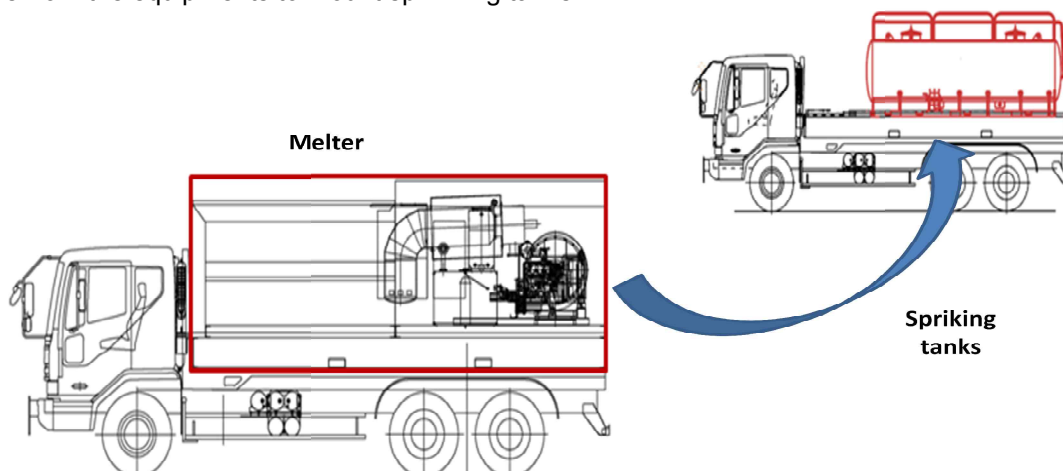


Figure 9 - A melter detachable

## 6. RESULTS

### 6.1. Effective road snow removal work

By a multi-purpose snow removal vehicle developed in this study, it is expected the vehicle can collect immediately remaining snow on the road while transporting and the melter can be in charge of new area in snow removal work. Involved in the smooth traffic flow and accident prevention, the vehicle is also expected to accelerate further advancement in the field of snow removal in heavy snow by improving the effectiveness of prevention of traffic issues

Also, although some problems of obtaining available space for snow removal work such as general plowing, etc, and the limitation of work environment still remain, it is expected to increase the efficiency of roads by efficient and systematic reorganization of snow removal work processes. Thus, by immediately responding to heavy snow, it can improve the road safety effects of winter through prompt and more complete snow removal work considering various work environments, including roadsides where there is not enough space available.

### 6.2. Daily road maintenance work

Because the period of use of snow removal equipments is relatively short by the nature of the climate in Korea, by being used in off-winter seasons, the vehicle is expected to alleviate various issues in terms of economic, operational and management aspects better than before for its high achievement in real life unlike existing snow removal equipments.

The multi-purpose snow removal vehicle developed in this study can be utilized with appropriate personnel management to fit the budget of road maintenance institution of each local government.

The vehicle also can be flexibly efficient to be used in daily multi purpose (sprinkling, tunnel cleaning, median strip cleaning, etc.) work in off-winter seasons.

## 7. CONCLUSIONS

Based on this study, we can promote the diversification of snow removal equipments by combining the multi-purpose snow removal vehicle with the technologies of existing snow removal equipments, enabling the export of the equipment to other countries overseas with climate characteristics similar to Korea. Through the exact analysis on climate, road traffic and existing road maintenance processes, substantial improvement on snow removal work is expected to produce more complete road maintenance guidelines in the field.

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