Snow property modeling and its application to particulate ice-snow flow computing in snowblower

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ABSTRACT

In Japan, about half of country is occupied by heavy snowfall area. Snowblowers are essential for people who live in such area and a high efficient snowblower is extensively required because quick snow removal closely related to the fuel efficiency.
Performance of a snowblower is mostly investigated by manipulation with an actual machine in heavy snowfall area. However, it is difficult to maintain stable experimental condition because snow properties are influenced by climate or regional effect. For the efficient development of a snowblower, stable and quantitative performance evaluation method is required.
In this study, we have developed a simulation method using DEM (Discrete Element Method) to reproduce snow removal. DEM is widely used as an effective method in granular flow, powder mechanics, rock mechanics and simple snow behavior in a snowblower. [1, 2, 3] However, it is difficult for DEM in application to reproduce unique behavior of snow because of the following reasons.

(1) Microscopically, snow contains multiple elements, such as ice, water and air. Its physical properties change depending on the ratio and geometrical configuration of such elements. Namely, it is difficult to consider actual snow structure in the simulation.

(2) Surrounding air flow cannot be computed by DEM. It is necessary to consider the fluid dynamic influence on snow lumps creation in various sizes.

(3) In spite of the fallen snow can maintain the initial shape even under gravitational field. Conventional DEM cannot be taken into account the initial shape of particles.

We constructed the advanced numerical model for DEM to elucidate the snow compaction behavior using Lenard-Jones potential model [4] which is conventionally used in molecular dynamics. This newly presented computational method can applicable to reproduce the detailed snow structure, and effective air drag only acting on lumped snow surface formed by particle aggregation as function of snow particle velocity. Furthermore, to reproduce the static behaviour of the fallen snow to maintain the initial shape, we have extended the numerical model to consider the constraint of tangential degrees of freedom and rotational degrees of freedom of snow particles.
As a result of present computational method, it was clarified that the detailed snow behavior in relation to snowblower can be successfully reproduced by simulation using DEM. The obtained computational results were compared with the experimental results, and found that both results exhibit reasonable agreements. Therefore, we have succeeded in the computational reproduction of quantitative snow behaviour in a snowblower using new snow property model.

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