Development of a System for Measuring the Volume of Snow-Accretion to Running Train Car Bodies

M. Shishido, S. Iikura, T. Fujii, T Endo, and Y. Kamata
(Railway Technical Research Institute)
K. Kawashima
(University of Niigata)
2-8-38,Hikari-cho Kokubunji-shi Tokyo 185-8540 JAPAN, iikura@rtri.or.jp

***Abstract*— In railway fields in Japan, preventive measures have been adopted to mitigate damage caused by snow for about 120 years since Japanese railways started transport service in snowy areas. In 1964, bullet train operation started between Tokyo and Shin-Osaka (i.e. the standard gauged Tokaido Shinkansen line) and then it has been extended to other regions including various snowy areas. In winter in snowy areas of the Tokaido Shinkansen line or the other extended Shinkansen lines, snow accretes to train car bodies while the train travels at high speed and drops away from them. Drop of snow makes flying ballast on the track fly up and the ballast damages the Shinkansen car bodies or houses built along the railway lines. In addition, trains on the meter gauged lines also travel at high speed recently, and the train car bodies or houses are sometimes damaged by drop of snow in winter. In winter in snowy regions, to mitigate the damage and improve the safety and punctual service of railways, we developed a system to measure the volume of snow accreted to train car bodies. This system applies the light cross section method and can measure the volume of the snow that has been accreted to train car bodies. The data of volume of snow accretion is immediately transmittable to arbitrary points through the Internet. The operating tests of the system performed at Sapporo station in winter revealed that the system is satisfactorily applicable to practical use.**

I. INTRODUCTION

When trains run in snowy areas in the snowy season, snow flies up from track surface and accretes to the train car bodies, for example equipment boxes and/or bogie. Snow accreted to the car bodies grows bigger gradually while the train travels at high speed, and drops onto track surface due to rise of air temperature, vibration are generated while the train runs and by gravity. This type of snow damage is well known after the standard gauged Tokaido Shinkansen line opened its transport service in 1964. As a ground side hardware countermeasure in Sekigahara area on the Tokaido Shinkansen line against the snow damage, sprinkling of water has been implemented to make snow on the track be wet. As a train car body side countermeasure, a flat plate has been mounted to cover the floor. Further, accreted-snow removal work has been carried out at stations, for example Nagoya station. Slow-down of train speed has also been implemented. Recently, trains of the meter gauged existing lines travel at high speed and then the train car bodies and/or houses are often also damaged by drop of snow in winter. As hardware countermeasure of the meter-gauged lines, covering ballast by ballast net or pasting films or sheets made of carbon material on window glass were carried out in addition to snow removal work and train speed reduction. Figure 1 shows the flow of process from accreting of snow onto car body to the occurrence of damage, and also shows countermeasures at each stage. For effective software countermeasures, it is important to gather the information of weather including snowfall, and information of volume of snow that is accreted to car bodies. We developed a system to measure the volume of snow that accreted onto train car bodies and to transmit the volume information to relevant arbitrary points (i.e. traffic control centers).

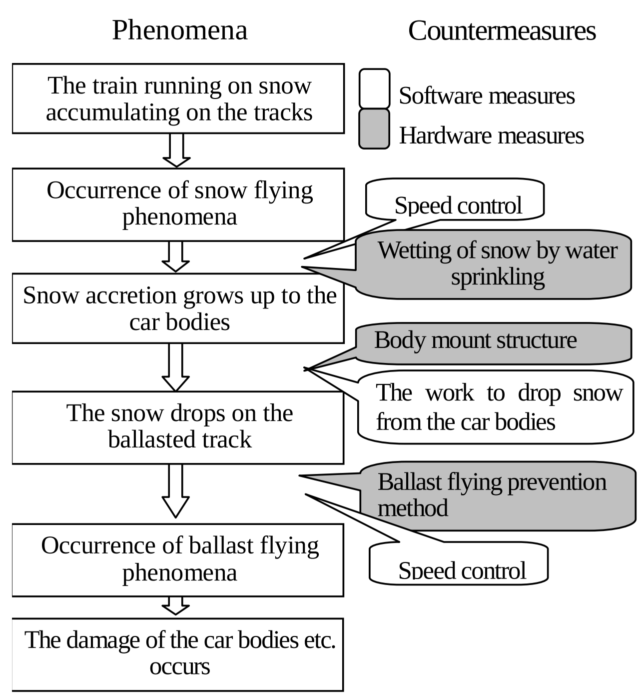

Fig. 1. Process of occurrence of ballast flying phenomenon

II. Outline of System Developed

The concept of the method to measure the volume of snow that is accreted to car body is as follows. As for the measurement of the amount of accretion adhesion of snow to the car bodies, it is necessary to measure in non-contact condition and in a short time. We have installed an illuminant that throws razor-sheet light and a high-speed camera under a platform, and then measured the lateral thickness of snow that is accreted to car body by means of light cross section method. The lateral thickness data obtained will be integrated into the volume data. The volume data are transmitted to relevant arbitrary points, through the Internet, along with pictures that show actual state of snow accretion.

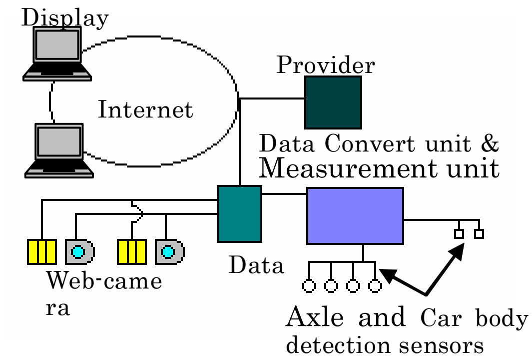

Fig. 3. Construction of the system

III. Method of Measurement and the Construction of the System

The Principle of method of measurement, i.e. the light cross section method, applies triangular surveying method that measures the distance between an illuminant and snow surface that is detected by razor-sheet light. Figure 2 shows the method of measurement by the light cross section method.

This system is composed of the measurement unit, the data convert unit, the axle and Car body detection sensors, the image camera (web-camera) and the data server (Figure 3, 4). Moreover, this system has the function to acquire data on the amount of snow accreted onto car body and the state of snow-accretion automatically with images by web-camera, and to transmit these data to any relevant points.

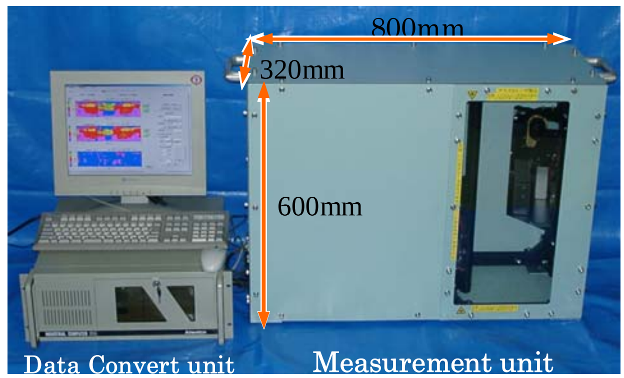

Fig. 4. Data Convert unit & Measurement unit

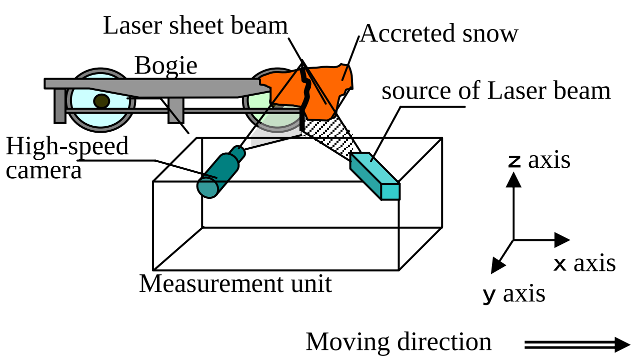

Fig. 2. Measuring method of accreted snow volume

IV. Operating Test

A series of operating tests was carried out at Sapporo station of JR Hokkaido in the 2003/04 and 2004/05 winter seasons.

The system was installed under the platform of Sapporo station as shown in Figure 5. We measured the accretion snow onto the side of bogie during winter seasons by using this system.

As the result of the long-term operating test at Sapporo station, it was confirmed that this system is able to measure the volume of snow accreted onto the side of car bogie automatically and continuously under the condition of cold weather environment.

The example of the accretion quantity data on the snow recorded with this system is shown in the Figure 6. The surface form data of accreted snow is shown in the part of the figure, middle part of figure shows the side view data of car bogie, and the bottom part of the figure shows the distribution of the difference (the accretion thickness of the snow) between the accretion quantity data on the snow and the form data on the side of the car bogie at every coordinate point .

The volume of accreted snow to the side of car bogie was about $0.2m^3$, and the maximum thickness was about 400mm with this measurement example.

Figure 7 shows the part with a remarkable growth of the snow accretion side of the car bogie. Remarkable snow accretion is recognized at the yaw damper, at the top of the bogie frame, at the front and back of the axle box suspension and at the braking rod. The distribution of the snow accretion showed a similar tendency about other data that had been obtained during winter. The snow accretion data and the image are displayed in the own homepage in the Internet at

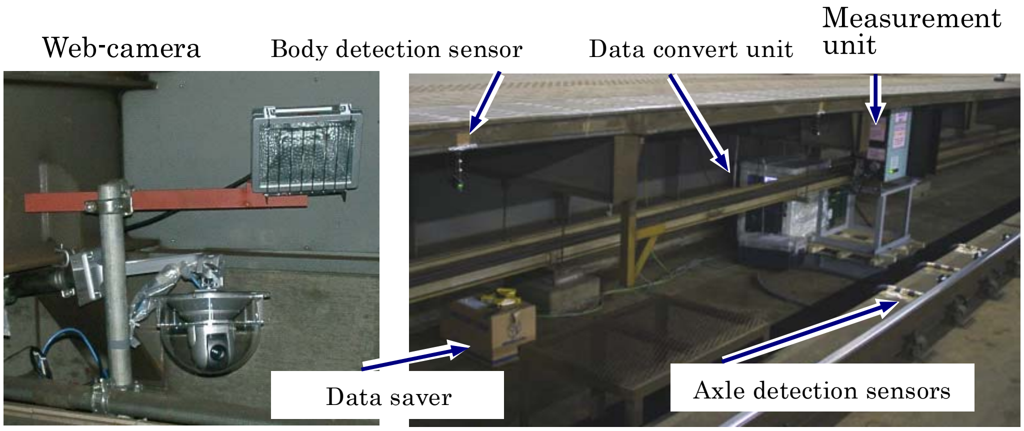

Fig. 5. Field test at Sapporo station

any time. This homepage is not open to the public, and only the person given the password can inspect the data. It took about five minutes for displaying the acquired data on the amount of adhesion of snow. It was also shown that it was an excellent practiced system for transmitting data on the amount of adhesion of snow because all the adhesion data on the snow acquired during the operating test could be transmitted.

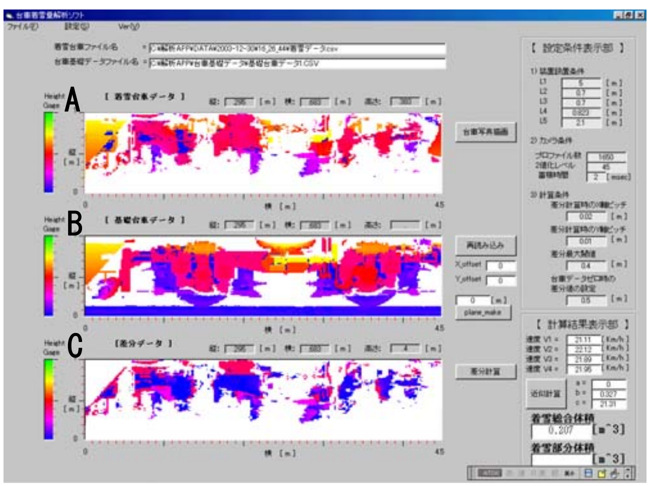

Figure 6 Example of measurement result

A: The surface form data of accreted snow on the bogie side

B: The surface form data of the bogie side

C: The distribution of the accretion thickness of the snow

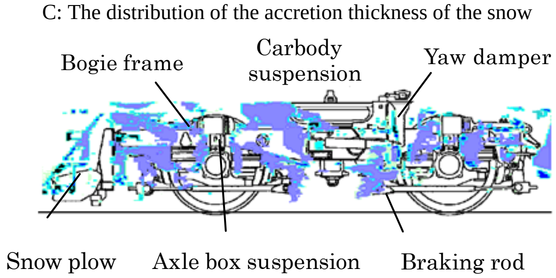

Fig. 7. Distribution of accreted snow on the bogie side

（Thickness over 10cm）

V. Summary

Data on the form of side of the base car bogie and form data on the form surface of the adhesion of the snow are acquired by the light cross-section method which laser seat light was used for, and this system finds the amount of adhesion of snow as between these two forms mentioned above. The measurement performance of this system is sufficient and excellent for practical use as a result of the operating examination. The amount of snow accreted to the train which arrives at the station can be measured automatically by installing this system in the station, and it was found out that the measurement information could be transmitted to any relevant the train service control places. In the near future, it will become possible to establish removed working plan of the accreted snow based on the weather prediction information, after deepening the analysis to make clear the relationship between the accretion quantity data on snow and weather condition.

Technical Reports:

[1] Kakinuma H., "The present state of railroad management of dealing with JR Hokkaido toward the safety stable transport (Japanese)," *The management of railway*, Vol.46, pp.7 - 9, NO.7, 2001.

[2] Takagi K. Takeshita K. and Sato M., "The realization of optical cutting-type rail section measurement device(Japanese) ", *RTRI Report*, Vol.13, pp.23-27, NO.5, 1999

Papers from Conference Proceedings (Published):

[3] Kawashima K., Iikura S., Endo T., Fujii T., Imai T. and Nakane T., "A measuring system for snow depth profiles in Maglev guide way using the light cross section method," In Izumi M., Nakamura T. and Sack, R. L., *ed. Snow Engineering: Recent Advances*, pp.105-108, 1997

[4] Kawashima K., Iikura S., Endo T. and Fujii T., " A device for measuring the quantity of snow accreted to running trains (Japanese)," *Reports of Cold Region Technology Conference,* Vol.19, pp.226-231, 2003

[5] Iikura S., Kawashima K., Endo T. and Fujii T., " A device for measuring the quantity of snow accreted to running trains (3rd) -Development of practical use system-(Japanese)," *The 2005th Japanese snow ice academic meeting national conference lecture materials* , 2005, pp.68 .