EVALUATION OF A PHYSICAL SNOW ACCRETION MODEL BY LABORATORY EXPERIMENT

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Abstract: Snow-resistant (SR) rings and counterweights (NBD) have been used by Hokkaido Electric Power to prevent snow accretion on transmission lines. These qualitative effects have been widely appreciated from observation and actual performance in Hokkaido. However, problem seems to lie in the fact that galloping is promoted by installing NBD on transmission lines. The installation standard of NBD at Hokkaido Electric Power has been determined by numerical computing results of a physical snow accretion model suggested by Goto in the 1970s. This model can compute the growing process to cylindrical-sleeve snow on a transmission line. Therefore, in order to optimize the installation standard of NBD, it is important that the accuracy of this model is elevated.

In this study, in order to arrange accuracy improvement of this model, the adequacy of this model has been evaluated by laboratory experiment using a test conductor. The test conductor, which has a length of about 1.5m, simulates a short part of a transmission line. It has the function of simulating the torsional rigidity of wiring of a conductor. We performed the experiment in a temperature-controlled room. In performing the experiment, the snowfall was reproduced by grinding down natural snow on metallic mesh. The wind was reproduced with the air blower. The data items collected are the angle of twist of the test conductor, the weight and outside diameter of snow accretion in the growing process to cylindrical-sleeve snow. The image of the growing process to cylindrical-sleeve snow on the test conductor was recorded.

From the results of the experiment, it has been reconfirmed that this model is valid, because the computing results of this model are similar to that of data and images collected in the experiment. Further, to improve the model more accurately, it has been found that it is important to evaluate properly the increasing amount of snow accretion on the test conductor surface.

1. INTRODUCTION

Snow-resistant (SR) rings and counterweights (NBD) have been used by Hokkaido Electric Power to prevent snow accretion of wet snow.[1] However, a problem seems to lie in the fact that galloping is promoted by installing NBD on transmission line.

The installation standard of NBD at Hokkaido Electric Power has been determined by numerical computing results of a physical snow accretion model suggested by Goto in the 1970s.[2] This model can compute the growing process to cylindrical-sleeve snow on a transmission line. Therefore, in order to optimize the installation standard of NBD, it is important that the accuracy of this model be elevated.

In order to arrange accuracy improvement of this model, the adequacy of this model has been evaluated by laboratory experiment using a test conductor.

2. RESULTS AND DISCUSSION

To evaluate the physical snow accretion model, we compared the numerical computing results with experimental results by using the following items:

- Comparison of the data. (The angle of twist of the test conductor, the weight and the maximum outside diameter of snow accretion)
- Comparison of the shape of snow accretion.

The data of numerical computing results (No.3) and the experimental results (No.1 and 2) are very similar. Figure 1 shows an example of that. The shape of the numerical computing results is similar to that of images collected in the experiment. However, the shape of snow accretion was slightly different in the early steps. It is suspected that the reason for this is that the increasing amount of snow accretion on the test conductor surface that grows in the direction of snowfall is the same.

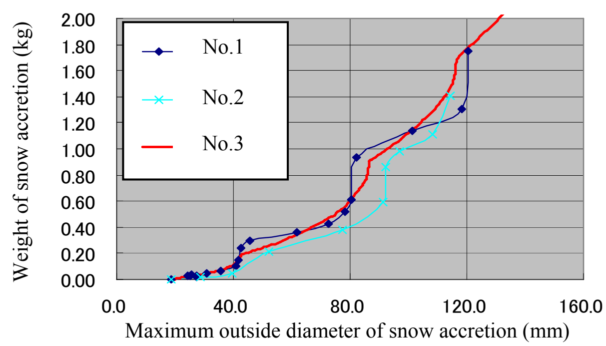

Figure 1: Comparison of the data (the weight : the maximum outside diameter of snow accretion)

3. CONCLUSION

From the results of this experiment, it has been reconfirmed that this model is valid, because the numerical computing results of this model are similar to that of data and images collected in this experiment. Further, to improve the model more accurately, it has been found that it is important to evaluate properly the increasing amount of snow accretion on the test conductor surface.

4. REFERENCES

[1] Keitaro Fujii, Tadahiro Takahashi, "Observation of natural snow accretion no test conductors" IWAIS'09, Session 6 PO.024, 2009.

[2] Kazuo Goto, "A simulation computation of twist of De-Snowing electric wires due to snow accretion" Journal of the Japanese society of Snow and Ice No.38, 1976. (in Japanese)

Evaluation of a Physical Snow Accretion Model by Laboratory Experiment

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***Abstract*—Snow-resistant (SR) rings and counterweights (NBD) have been used by Hokkaido Electric Power to prevent snow accretion on transmission lines. These qualitative effects have been widely appreciated from observation and actual performance in Hokkaido. However, problem seems to lie in the fact that galloping is promoted by installing NBD on transmission lines. The installation standard of NBD at Hokkaido Electric Power has been determined by numerical computing results of a physical snow accretion model suggested by Goto in the 1970s. This model can compute the growing process to cylindrical-sleeve snow on a transmission line. Therefore, in order to optimize the installation standard of NBD, it is important that the accuracy of this model is elevated.**

In this study, in order to arrange accuracy improvement of this model, the adequacy of this model has been evaluated by laboratory experiment using a test conductor. The test conductor, which has a length of about 1.5m, simulates a short part of a transmission line. It has the function of simulating the torsional rigidity of wiring of a conductor. We performed the experiment in a temperature-controlled room. In performing the experiment, the snowfall was reproduced by grinding down natural snow on metallic mesh. The wind was reproduced with the air blower. The data items collected are the angle of twist of the test conductor, the weight and outside diameter of snow accretion in the growing process to cylindrical-sleeve snow. The image of the growing process to cylindrical-sleeve snow on the test conductor was recorded.

From the results of the experiment, it has been reconfirmed that this model is valid, because the computing results of this model are similar to that of data and images collected in the experiment. Further, to improve the model more accurately, it has been found that it is important to evaluate properly the increasing amount of snow accretion on the test conductor surface.

Keywords-component; Snow Accretion,Transmission Line, Model, Cylindrical-sleeve Snow, Growing Process

I. INTRODUCTION

Wet snow has caused snow accretion that leads to large snow disasters in Hokkaido.[1] The snow accretion on small outside diameter conductors having a long span grows into large cylindrical-sleeve snow by eccentric moment of the snow accretion. This growing process is shown in Figure 1.

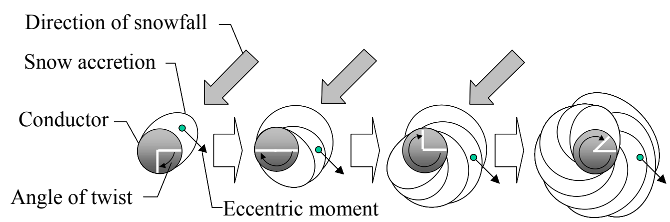

Figure 1. Growing process of snow accretion on a small outside diameter conductor having a long span (corss section)

Snow-resistant (SR) rings and counterweights (NBD) have been used by Hokkaido Electric Power to prevent snow accretion of wet snow.[2] Because, NBD has a function of disturbing the twist of the conductor, it is difficult to grow large cylindrical-sleeve snow by the eccentric moment of snow accretion twisting the conductor. These qualitative effects have been widely appreciated from observation and actual performance in Hokkaido. However, a problem seems to lie in the fact that galloping is promoted by installing NBD on a transmission line.

The installation standard of NBD at Hokkaido Electric Power has been determined by numerical computing results of a physical snow accretion model suggested by Goto in the 1970s.[3] This model can compute the growing process to cylindrical-sleeve snow on a transmission line. Therefore, in order to optimize the installation standard of NBD, it is important that the accuracy of this model be elevated.

In this study, in order to arrange accuracy improvement of this model, the adequacy of this model has been evaluated by laboratory experiment using a test conductor. This paper describes the results of the evaluation.

II. PHYSICAL SNOW ACCURATION MODEL

This model, suggested by Goto in the 1970s, can compute the growing process to cylindrical-sleeve snow on a transmission line (wiring of a conductor) after snow adheres to the conductor surface. Input data items of this model are the outside diameter of conductor, the density of snow accretion, the division number of the span, the increasing amount of snow accretion per step, the torsional rigidity of conductor, etc. So, the output data items are the shape of snow accretion, the weight of snow accretion, the angle of twist of the conductor, etc.

This model computes the influence of snow accretion increasing on each part where the span is divided equally. The dividing method is shown in Figure 2. And the snow accretion increases parallel to the direction of snowfall in only the area facing the direction of snowfall. The details of the growing process of snow accretion are shown in Figure 3. A computation process is as below:

- These sectional areas and center of gravity of snow accretion increasing on each part is computed.
- The eccentric moment of each snow accretion is computed from the density of snow accretion, the sectional areas and center of gravity thereof.
- The angle of twist in each part is computed from the eccentric moment and the torsional rigidity of the conductor, using a static load.

The above defined as one step. The growing process of snow accretion is computed by repeating the step.

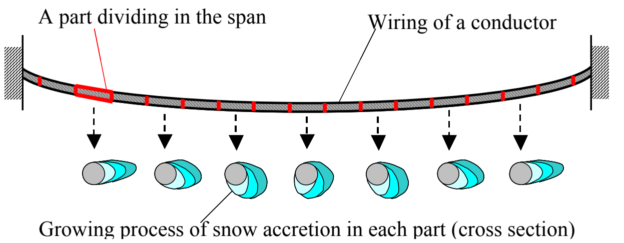

Figure 2. The dividing method in the span

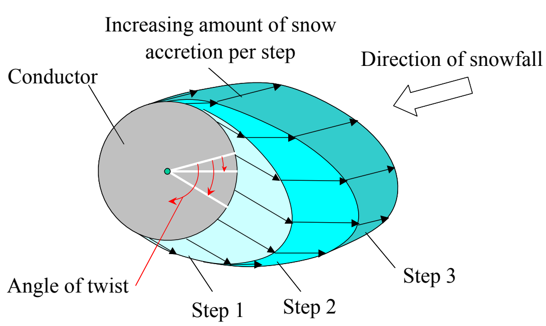

Figure 3. Growing process of snow accretion (detail)

III. Laboratory Experiment Of Snow Accretion

It is best to evaluate the numerical computing results of this model by using the actual observational results. However, it is difficult to obtain that data. Therefore, the numerical computing results have been evaluated by using the laboratory experimental results.[4] Similar experiments have been conducted by the manufacturer and another electric power company etc.[5] This chapter describes the experiment and the results of the experiment.

A. Experimental apparatus

Figure 4 shows the configuration of experimental apparatus. The main experimental apparatus consists of a metallic mesh, an air blower, a test conductor and a load cell on a stand. The experimental apparatus was used in a temperature-controlled room. In performing the experiment, the snowfall was reproduced by grinding down natural snow on the metallic mesh. The natural snow was used after the snow moisture content value was adjusted. The wind was reproduced with the air blower. The data items collected were the angle of twist of the test conductor, the weight and outside diameter of snow accretion in the growing process to cylindrical-sleeve snow. The image of the growing process to cylindrical-sleeve snow on the test conductor was recorded.

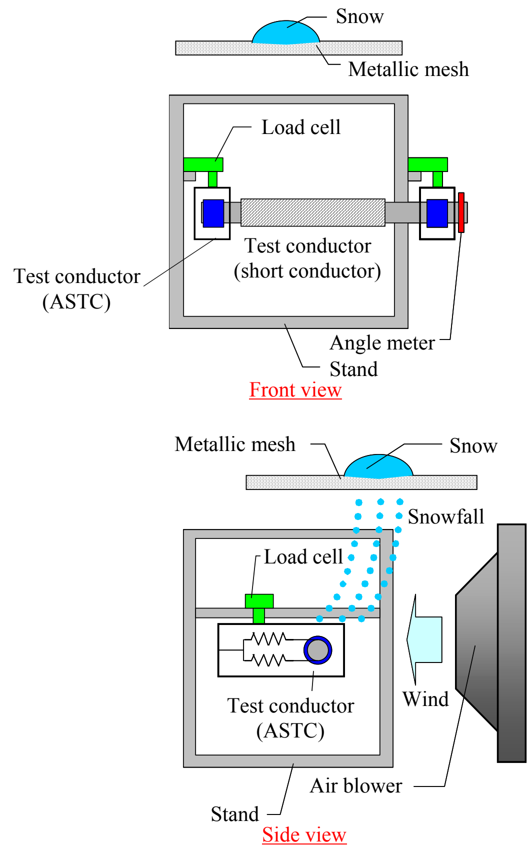

Figure 4. Configration of the experimental apparatus

The test conductor simulates a short part of a transmission line. This consists of a short conductor and the apparatus simulating the twist characteristic of wiring of a conductor (ASTC). The short conductor is wrapping of strands around a stainless pipe that has the length of about 1.5m. ASTC has the function of simulating the torsional rigidity of wiring of a conductor. The detail of ASTC is shown in Figure 5.

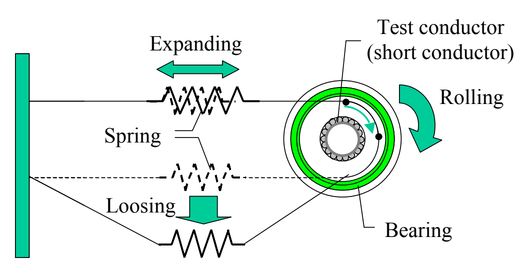

Figure 5. ASTC(detail)

B. *Experimental conditions*

TABLE I. shows the experimental conditions. The torsional rigidity of the test conductor is smaller than that of a general conductor, because it allows for the cylindrical-sleeve snow growth factor. It is calculated from the actual measurement value as the center point of the span (500[m]).

TABLE I. EXPERIMENTAL CONDITIONS

Type	Specific settings
Type of test conductor	ACSR160 (o.d.18.8 mm)
Torsional rigidity of the test conductor (kg-m^2/rad)	0.1125
Wind velocity (m/s)	5
Snow moisture content (%)	5～15
Temperature in the temperature-controlled room (℃)	About 2

C. *Experimental results*

In the experiment, we obtained results for two cases. The data collected at the end of the experiment is shown in TABLE Π. The snow accretion conditions at the end of the experiment (No.2) are shown in Figure 6.

TABLE II. EXPERIMENTAL RESULTS

Item	No.1	No.2
Weight of snow accretion (kg)	1.750	1.141
Angle of twist of the test conductor (degree)	468	405
Maximum outside diameter of snow accretion (mm)	120.60	114.38
Length of snow accretion (mm)	700	700
Density of snow accretion (g/cm^3)	0.41	0.37

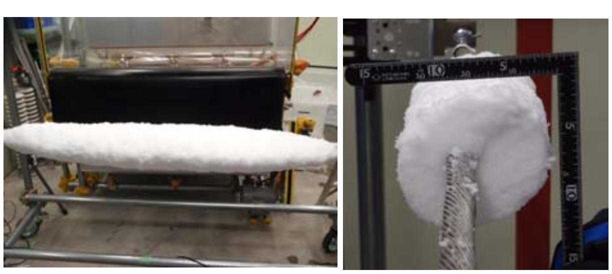

Figure 6. Snow accretion conditions at the end of the experiment (No.2)

IV. COMPARATIVE EVALUATION OF PHYSICAL SNOW ACCRETION MODEL

To evaluate the physical snow accretion model, we compared the numerical computing results with experimental results by using the following items:

- Comparison of the data. (the angle of twist of the test conductor, the weight and the maximum outside diameter of snow accretion)
- Comparison of the shape of snow accretion.

Input data on the computing are set based on the experimental conditions and results.

A. *Comparison of the data*

Figure 7. shows the data of numerical computing results and the experimental results. The numerical computing results (No.3) and the experimental results (No.1 and 2) are very similar. And No.3 has the characteristic curves of No.1 and 2.

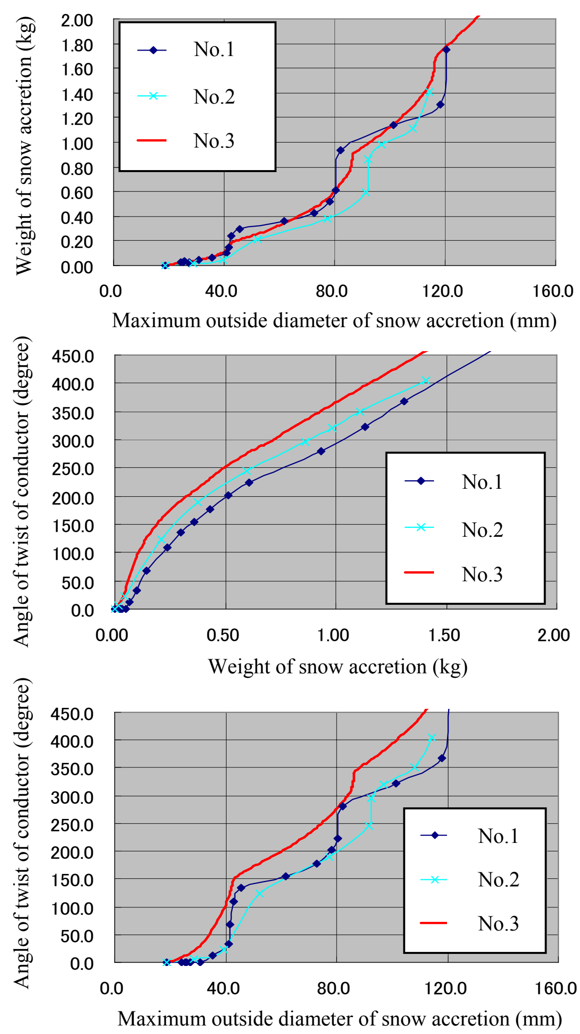

Figure 7. Comparison of the data

B. *Comparison of the shape of snow accretion*

Figure 8. shows the shape of snow accretion for both the experimental results (No.2) and numerical computing results (No.3). It has been reconfirmed that this model is valid, because the shape of the numerical computing results is similar to that of images collected in the experiment. However, the shape of snow accretion was slightly different in the early steps. It is suspected that the reason for this is that the increasing amount of snow accretion on the test conductor surface that grows in the direction of snowfall is the same, shown in Figure 9.

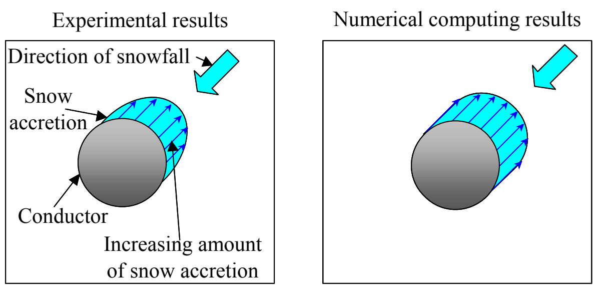

Figure 9.The shape of snow accretion in the early step

V. CONCLUSIONS

From the results of this experiment, it has been reconfirmed that this model is valid, because the numerical computing results of this model are similar to that of data and images collected in this experiment. Further, to improve the model more accurately, it has been found that it is important to evaluate properly the increasing amount of snow accretion on the test conductor surface.

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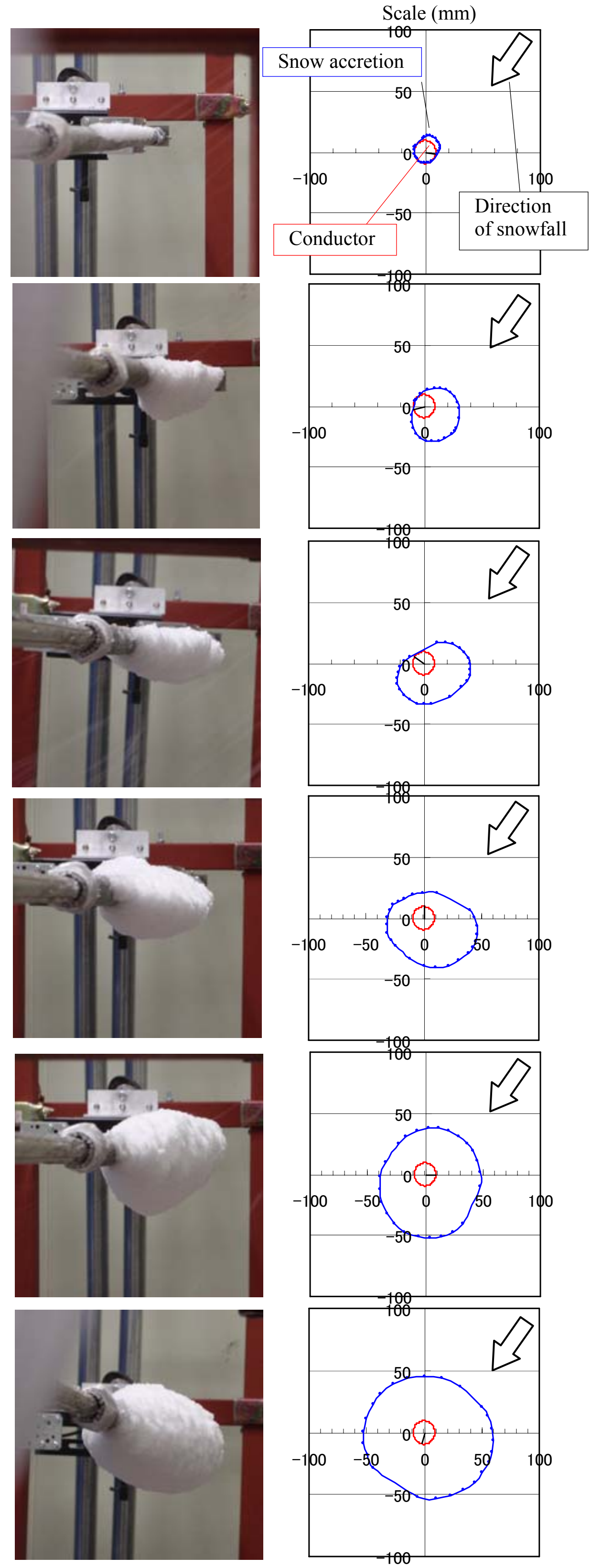

Figure 8. Comparison of the shape of snow accretion
(L : Experimental results, R : Numerical computing resuls)