Observation of Natural Snow Accretion on Test Conductors

Keitaro Fujii*
*Hokkaido Electric Power Co., Inc.
*2-1, Tsuisikari, Ebetsu, Hokkaido 067-0033, Japan, *+81-11-385-6302, *h2002016@epmail.hepco.co.jp

Tadahiro Takahashi**
**J-Power Systems Corp.
**Toyoura Works, 4-10-1, Kawajiri, Hitachi, Ibaraki, 319-1411, Japan, **+81-294-43-2131,
**takahashi.tadahiro@jpowers.co.jp

Abstract —Snow accretion on an overhead transmission line increases line tension by the weight and wind load, and gives the line excessive stress. Serious snow accretion is a rare phenomenon. However, it may cause the conductor and the tower to be damaged, if it should occur. That is the reason Hokkaido Electric Power have used a snow-resistant (SR) ring and a counterweight as countermeasures. These qualitative effects of snow accretion resistance are widely admitted from past performance. However, there is little quantitative data of these effects. Moreover, we have little quantitative data of the amount of the snow accretion of lines with interphase spacers.

It is extremely important to evaluate a quantitative amount of the snow accretion, when making sure the effect of these snow disaster countermeasures (SR ring, Counterweight, interphase spacer). Therefore, since November 2007, we have observed the meteorological data that occur snow accretion (that especially twists the conductor and develops) and the developing process in a variety of line conditions. The purpose of this observation is to clarify the difference of the snow accretion situation by overhead line conditions, and to clarify the relationship between the snow accretion and the meteorological data.

To observe them, we have set up the test conductors, the meteorological observation devices and the snow accretion observation devices at the test site in Hokkaido (one region of Northern Japan). The test conductor is a short conductor with the mechanism of rotating around the axis and with an apparatus that installs torsional rigidity with a spring. These test conductors simulate one point of the conductor on the span of various transmission lines.

This paper describes the analysis results of the observational data, and the considerations by it.

I. INTRODUCTION

The transmission line is confronted with various natural phenomenon. One of natural phenomena is snow accretion. Snow accretion on an overhead transmission line increases line tension by the weight and wind load, and gives the line excessive stress. Serious snow accretion is a rare phenomenon. However, it may cause the conductor and the tower to be damaged, if it should occur.

A wet snow causes serious snow accretion that leads to large snow disaster in the winters in Hokkaido. [1] The wet snow falls before the low pressure approaches or passes. Generally, the snow accretion by this snow has a high density (0.6-0.8 g/cm^3), and sometimes the wind velocity is 10 m/s or greater. The occurred air temperature belt is in the range from -1.5 °C to +1.5 °C. [2]

Snow accretion on a small conductor grows toward the windward side first, and then rotates around the conductor, and finally develops to a cylindrical-sleeve snow. Also, in the case of a long span, the eccentric weight of snow accretion will cause the conductor to twist. [2] This process is shown in Fig.1.

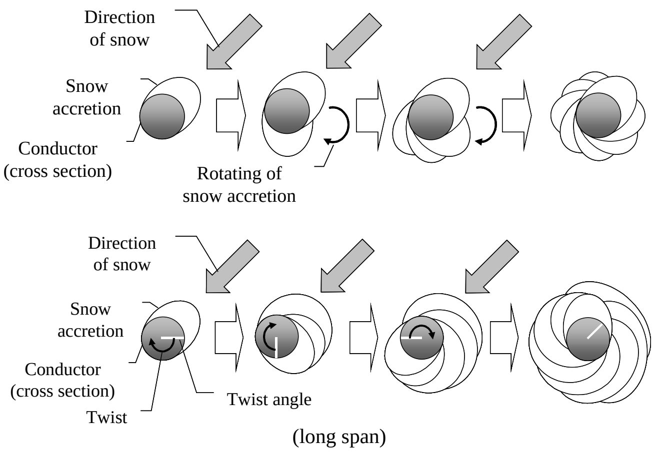

Fig. 1. Process of snow accretion (wet snow) on a small conductor

Presently, Hokkaido Electric Power uses countermeasures including a snow-resistant (SR) ring (Fig.2) and a counterweight (Fig.3). The SR ring works to disturb the development to cylindrical-sleeve snow by snow accretion rotating down along strands of conductors. The SR ring disrupts the snow accretion that rotates down along strands of conductors. For conductors installed with a counterweight it is difficult for twist to occur. These countermeasures protect the line from developing to cylindrical-sleeve snow. These qualitative effects of snow accretion resistance are widely admitted from past performance. However, there is little quantitative data about these effects.

Fig. 2. Snow-Resistant (SR) ring

Fig. 3. Counterweight

An interphase spacer adopted as a galloping countermeasure in the company gives to the transmission line the receiving wind pressure and the weight. Also it divides the span. Each span divided with an interphase spacer is considered to be a short span transmission line. Therefore, it can't twist more easily than a transmission line of a similar span length. From the above-mentioned, it is considered that the amount of snow accretion decreases by installing an interphase spacer. But we have little quantitative data of the amount of snow accretion on lines with interphase spacers.

It is extremely important to evaluate a quantitative amount of snow accretion, when making sure the effect of these snow disaster countermeasures (SR ring, Counterweight, interphase spacer). Therefore, since November 2007, we have observed the meteorological data that occur snow accretion (that especially twists the conductor and develops) and the developing process in a variety of line conditions. [3] The purpose of this observation is to clarify the difference of snow accretion situation by the overhead line conditions, and to clarify the relationship between the snow accretion and the meteorological data.

To observe them, we have set up the test conductors, the meteorological observation devices and the snow accretion observation devices at the test site in Hokkaido. The test conductor is a short conductor with the mechanism of rotating around the axis and with an apparatus that installs torsional rigidity with a spring. These test conductors simulate one point of the conductor on the span of various transmission lines.

This paper describes the analysis results of the observational data, and the considerations by it. The targeted observation period was from November, 2007 to March, 2009 (except the periods from April to October).

II. Outline of the Test Site

A. Snow accretion observation system

The snow accretion observation system is equipment used in this observation. This is observation equipment that integrates two equipment groups. One is the test conductor (equipment that simulates points on transmission lines of a variety of line conditions by short conductors, and an apparatus that installs torsional rigidity). Another is equipment that observes the meteorological data and the snow accretion on test conductors.

This system was set up at the Hokkaido Electric Power site in Ebetsu City in the west side region in Hokkaido. (Fig.4) The area required to set up the equipment is about 300 m^2 (The length: about 16 m and the width: about 18 m), excluding the lighting equipment at nighttime. (Fig.5)

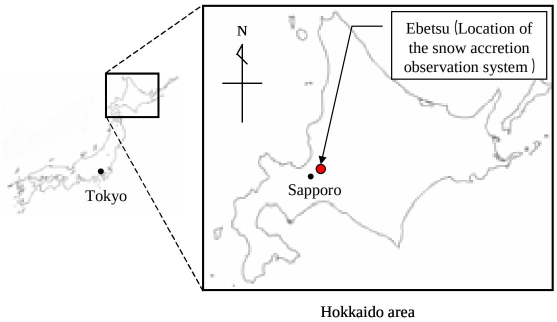

Fig. 4. Location of the snow accretion observation system

Fig. 5. The snow accretion observation system

B. Composition of equipment

The outline of the equipment that composes the snow accretion observation system is shown in TABLE 1.

TABLE 1
OUTLINE OF THE COMPOSITION OF SNOW ACCRETION OBSERVATION SYSTEM EQUIPMENT

Composition of equipment	Outline
Test conductor	Kinds of simulated condition : 12 Length : about 2250mm It sets up an apparatus that installs torsional rigidity at the edge. This axis is set up in a north-south direction. (The predominant wind direction in winter is the west.)
Observational equipment of snow accretion	Measuring weight of snow accretion (Load cell) Measuring of rotating angle of test conductor (Potentiometer) Taking a picture of snow accretion situation (Video camera)
Observational equipment of meteorological data	Wind velocity and Wind direction Air temperature and Humidity Snow depth Precipitation Solar insolation

C. Simulated conditions of the test conductors

Simulated conditions of the test conductors set up in the snow accretion observation system is shown in TABLE 2. The simulated torsional rigidity with spacer installation is the torsional rigidity in the center point of the sub-span of the transmission line with three interphase spacers in a span. The simulated torsional rigidity with the counterweight is torsional rigidity in the center point of the span of the transmission line with two counterweights in a span. The sub-span is the subsection of a span between the installation point of an interphase spacer and the edge of the span.

TABLE 2
SIMULATED CONDITIONS OF THE TEST CONDUCTORS

Type	Simulated conditions of the test conductors				
	Conductor Size	Span *2	Ring *3	CW *4	IS *5
A	ACSR160 (o.d.18.2 mm)	300 m	--	--	--
B	ACSR160 (o.d.18.2 mm)	300 m	+	--	--
C	ACSR160 (o.d.18.2 mm)	300 m	+	+	--
D	ACSR160 (o.d.18.2 mm)	300 m	+	--	+
E	ACSR160 (o.d.18.2 mm)	400 m	+	--	--
F	ACSR160 (o.d.18.2 mm)	400 m	+	+	--
G	ES-ACSR*1160 (equivalent o.d.17.8 mm)	300 m	--	--	--
H	ACSR610 (o.d.34.2 mm)	300 m	+	--	+
I	ACSR610 (o.d.34.2 mm)	300 m	--	--	--
J	ACSR610 (o.d.34.2 mm)	300 m	+	+	--
K	ACSR610 (o.d.34.2 mm)	300 m	+	--	--
L	ES-ACSR*1610 (equivalent o.d.32.4 mm)	300 m	--	--	--

+ : Simulated, -- : NOT Simulated
*1 : Spiral-Elliptic Conductor (product of J-Power Systems Corp.)
*2 : The center point of the span in the table is simulated. When an interphase spacer is simulated, it is the center point of the sub-span.
*3 : Snow-Resistant (SR) ring
*4 : Counterweight
*5 : Interphase spacer

D. Apparatus that installs torsional rigidity

The sketch of installation into the stand of the test conductors is shown in Fig.6. The test conductors are hung on the load cell installed into the stand.

The conceptual sketch of the apparatus that installs torsional rigidity is shown in Fig.7. The apparatus simulates the torsional rigidity by using spring. The performance of the spring in the apparatus is different on each simulated condition.

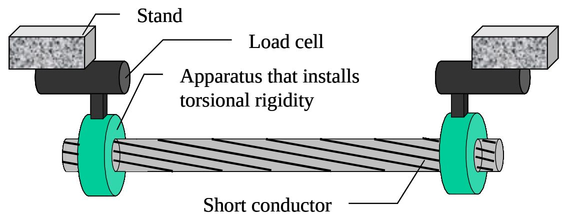

Fig. 6. Sketch of the test conductors

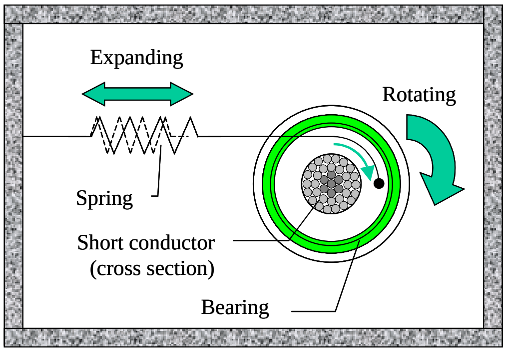

Fig. 7. Conceptual sketch of the apparatus that installs torsional rigidity

III. RESULT

In the observation from November, 2007 to March, 2009 (except the periods from April to October), there were nine cases in which the period of development of comparatively significant snow accretion had been confirmed. From the picture of the snow accretion, the snow accretion situation was snow on a test conductor (Fig. 8) in each case of these nine cases. Then the snow accretion dropped without developing to cylindrical-sleeve snow.

The observational result in the period of development of snow accretion in these nine cases is shown in TABLE 3.

TABLE 3 shows the following:

- The maximum developed amount of snow accretion in nine cases was 0.6 kg/m (caseNo.1, Type. K).
- Type to which the maximum developed amount of snow accretion in each case was observed was a group of type ACSR610 (o.d.34.2 mm).
- The range of temperature was from -8.1 °C to +0.5 °C.
- The wind velocity was in the range of 5 m/s or less.

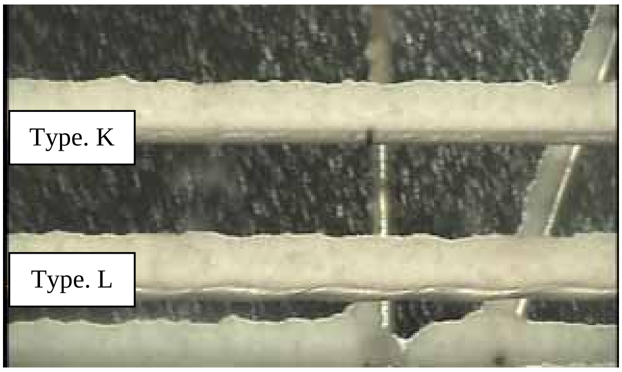

Fig. 8. The snow accretion (Case No.1)

TABLE 3
OBSERVATIONAL RESULT IN THE PERIOD OF DEVELOPMENT OF SNOW ACCRETIONS IN THESE NINE CASES

Case No.	Observational result			
	Type	Snow accretion *1 (kg/m)	Wind velocity*2 (m/s)	Air temperature*2 (°C)
No.1 (2007/12/13)	K	0.6	0.6	-0.5
No.2 (2007/12/29)	I	0.3	2.1	-0.3
No.3 (2008/01/30)	J	0.2	0.4	-6.4
No.4 (2008/02/27)	I	0.3	0.6	-8.1
No.5 (2008/11/22)	J	0.4	1.5	+0.0
No.6 (2008/12/31)	H	0.2	4.7	-1.0
No.7 (2009/01/10)	J	0.2	1.5	-1.6
No.8 (2009/01/14)	H	0.2	3.9	0.5
No.9 (2009/01/20)	J	0.2	0.3	-1.9

*1: Maximum developed amount of a snow accretion in the period
*2: A mean value

IV. DISCUSSION

Conditions of the snow accretion estimated from air temperature and wind velocity

The air temperature and wind velocity remarkably influence the occurrence and development of the snow accretion. [4] It is considered that the air temperature influences snowflake condition (moisture content), and the wind velocity influences accreting condition of snowflakes and falling away snow accretion.

We tried to estimate the condition of snow accretion from the air temperature data and wind velocity data. From the observational result of a mean value for ten minutes in the period of development of snow accretion in these nine cases, we weighed the ratio of the air temperature range between "lower than 0 °C" and "0 °C or greater", with the results being shown in TABLE 4. Moreover, the ratio of the wind velocity range between "3 m/s or less" and "greater than 3 m/s" is shown in the same table.

TABLE 4 shows that, as for the cases No.1 and No.2 with a high ratio of the air temperature range of lower than 0 °C, the ratio of wind velocity range of 3 m/s or less was extremely high. Also, as for the cases No.3, No.4, No.7 and No.9 where only the air temperature range of lower than 0 °C was observed, the ratio of wind velocity range of 3 m/s or less was extremely high. It is considered that this causes snow with extremely low moisture content in the air temperature range of lower than 0 °C. Therefore, it is presumed that snow with extremely low moisture content (dry snow) tends to develop for periods when the wind is weak (there is little influence on snow accretion by the wind) because the adhesion force is small.

TABLE 4
RATIO OF THE AIR TEMPERATURE AND WIND VELOCITY IN THE PERIOD OF DEVELOPMENT OF SNOW ACCRETIONS IN THESE NINE CASES

Case No.	Air Temperature		Wind velocity	
	lower than 0 °C	0 °C or greater	3 m/s or less	greater than 3 m/s
No.1 (2007/12/13)	84%	16%	100%	0%
No.2 (2007/12/29)	60%	40%	67%	33%
No.3 (2008/01/30)	100%	0%	100%	0%
No.4 (2008/02/27)	100%	0%	100%	0%
No.5 (2008/11/22)	50%	50%	85%	15%
No.6 (2008/12/31)	42%	58%	25%	75%
No.7 (2009/01/10)	100%	0%	100%	0%
No.8 (2009/01/14)	0%	100%	33%	67%
No.9 (2009/01/20)	100%	0%	100%	0%

As for the case No.8 where only the air temperature range of 0 °C or more was observed, the ratio of wind velocity range of greater than 3 m/s was high. Also, as for the case No.6 with a high ratio of the air temperature range of 0 °C or greater, the ratio of wind velocity greater than 3 m/s was high. It is considered that this shows that snow accretion developed even when the wind is strong. It is guessed that the snow with rising moisture content in the temperature of 0 °C or more adheres easily and has a condition to which the snow accretion doesn't easily fall, because the adhesion force grows.

V. CONCLUSION

Up to now, a phenomenon that develops into cylindrical-sleeve snow while twisting the conductor, which was the main object of the observation, has not occurred yet. We suppose that one of the reasons is that it is a very rare phenomenon. However, from as many as nine cases, we have obtained profitable observational data of the snow accretion situations, and the meteorological data when it developed.

We are going to continue these observations and acquire data to evaluate the amount of quantitative snow accretion on a transmission line.

VI. REFERENCES

[1] Japanese Society of Snow and Ice, "Problems and Counter Measures related to Snow and Ice Effects on Power Transmission Lines" *Research on Snow and Ice No.5*, pp. 102, Jun. 1973.(in Japanese)

[2] Shuichi Asai, Akihiko Mayumi, "Improvement of countermeasures for snow accretion" *IWAIS'90, SESSION B7-2-(1), 1990* .

[3] Keitaro Fujii, Tadahiro Takahashi, "Observation of Natural Snow Accretion on the Test Conductors -Last winter-" JSSI & JSSE Joint Conference –2008/Tokyo, *SESSION C3-09, 2008* .(in Japanese)

[4] Japanese Society of Snow and Ice, "Problems and Counter Measures related to Snow and Ice Effects on Power Transmission Lines" *Research on Snow and Ice No.5*, pp. 9, Jun. 1973.(in Japanese)