Technical Challenges of Lightning Protection for Wind Power Generation

○Takayuki Nakamoto　Hiroshi Morita　(Kinden)

1. Introduction

Power generation utilizing wind energy has recently become widespread all over the world as a renewable energy supply that can realize global environmental protection and stable energy supply at the same time.

While it is also widespread in Japan, the number of troubles due to lightning such as equipment damage, dielectric break down, etc. has been increasing. Especially, Japan bumps into serious problems that blades are damaged by direct lightning strokes.

This talk will introduce our countermeasures against lightning stroke problems for wind power generation.

2. Lightning and lightning damage in Japan

2.1 Characteristics of lightning in Japan

There are two different aspects of lightning in Japan. One of them is called summer season lightning (from April to October), and the other is winter season lightning (from November to March). The respective characteristics include the following:

(1) Summer season lightning

1. Thundercloud reaches more than 12,000m altitude.
2. More than 90% electric discharges from thundercloud are negative electrode.
3. It is more likely that the direction of discharge is from thundercloud to the ground (Refer to Fig. 1).

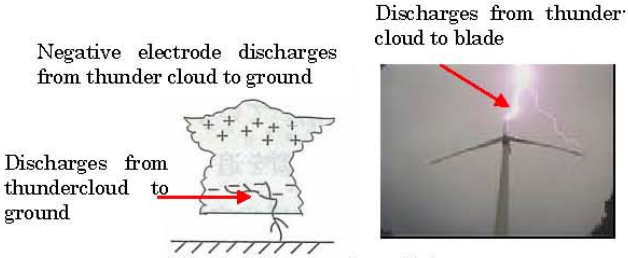

Fig. 1: Negative electrode in summer

(2) Winter season lightning

1. Thundercloud is located close to the ground level. 2.30%～50% of lightning is positive electrode whose wave tale (several hundred msec.) is longer than negative electrode.
3. It is more likely that the direction of discharge is from the ground to thundercloud (Refer to Fig. 2).

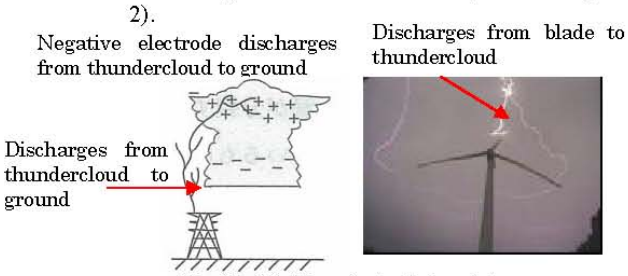

Fig. 2: Positive electrode in winter

2.2 The actual lightning damages on wind-power generators in Japan

(1) The number of lightning and damages

The distribution map of lightning and damages which were monitored in Japan from 2002 to 2004 is shown hereunder (Refer to Fig. 3 for winter lightning and Fig. 4 for summer lightning; excerpts from Wind Power Generation Guideline/Countermeasures For Lightning, Page 7, 8 published by NEDO).

According to the data, the lightning strokes in summer are more than in winter, but in winter (more lightning along the Sea of Japan), there is a tendency to bring more damages on wind-power generators than in summer .

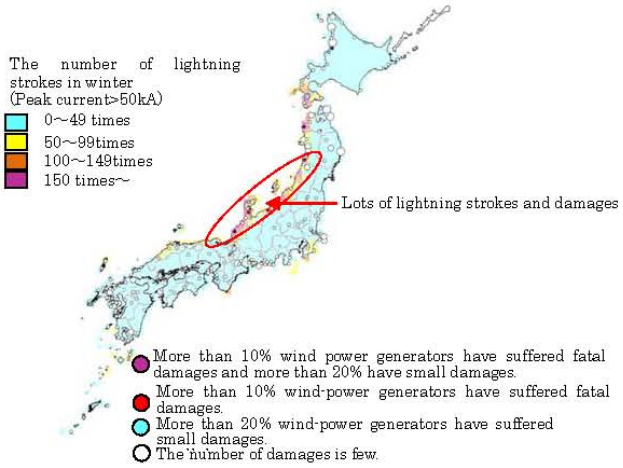

Fig. 3: Lightning map in winter

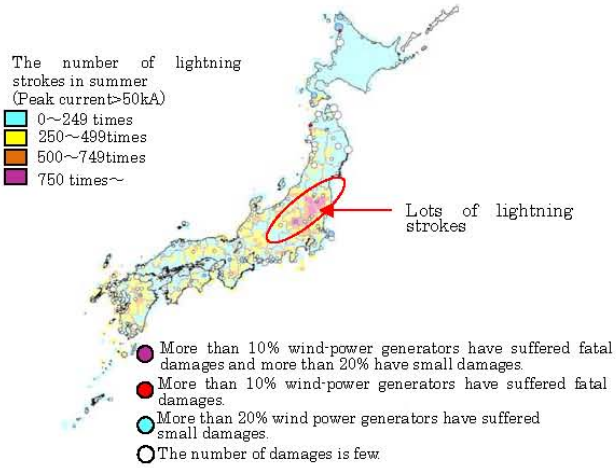

Fig. 4: Lightning map in summer

(2) Aspects of damages by lightning

The aspects of damages differ according to the stroke position of lightning. The aspects of damages on wind-power generator are shown Fig.5

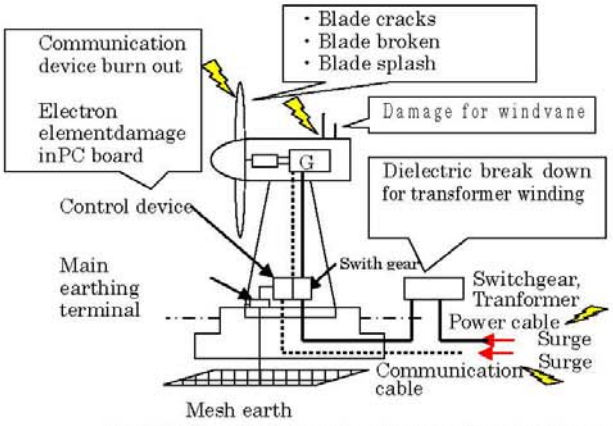

Fig.5Wind-power generation damage due to lightning

3. Lightning protection system for wind-power generator

We are studying the lightning protection system design for wind-power generator reviewing lightning troubles on generators in the past. We introduce our study examples as follows:

(1)Review of effective lightning protection of blades

It is told that the stroke position and pathway of lightning is not uniform as following case.

1.Stroking at receptor and flowing inside blade.(Refer to pic.1)
2.Stroking at drain hole and flowing inside blade.
3.Stroking at blade surface (not receptor or drain hole)and flowing along it.(Refer to pic.2)
4.Stroking at blade surface such as No.3 ,passing through to the inside blade and flowing inside.
5. Stroking at blade surface such as No.3 ,flowing along it, and passing through to the inside on the way.

Stroking at receptor.

Pic1.Stroking at receptor.

Creeping discharge

Pic2.Creeping discharge

The aspects of damages to the blade are different according to above each case.

Considering above, we review the non traditional lightning protection of blade with manufacturer.

(2) Equipotential earthing

1. Connect earthing system with wire armor which is originally for wire protection sheath.
2. Install earthing system with the closest equivalent resistance value of each wind-power generator .
3. Connect all conductive parts with bonding earth.

(3) Setting transformer and 22kV switchgear inside the tower

When we design a win-farm system, we adopt following methods.

1. Transform the voltage from AC575V or 690V (generator's standard voltage) to 22kV by step-up transformer.
2. Wire to the substation via 22kV switchgear.
3. Transform 22kV to 66kV or 77kV at a substation and connect to the grid.

In case the step-up transformer and 22kV switchgear are installed outside the tower, the difference in potential may be created at a transformer by lightning due to the ground impedance. Therefore, as a countermeasure, we set them inside the tower. As a result, it makes possible to minimize the difference in potential by lightning because the ground impedance of them is reduced.

(4) Reducing earthing resistance value

We put the value of resistance between main earthing terminal and grounding at less than 2 ohm in effect. The grounding is conducted by mesh earth.

Furthermore, we use whisker which is effective to reduce surge impedance.

(5)Using non metallic optical fiber cable as communication cable

Surge current also invades the communication cable. As a countermeasure, we use non-metalic optical fiber cable .

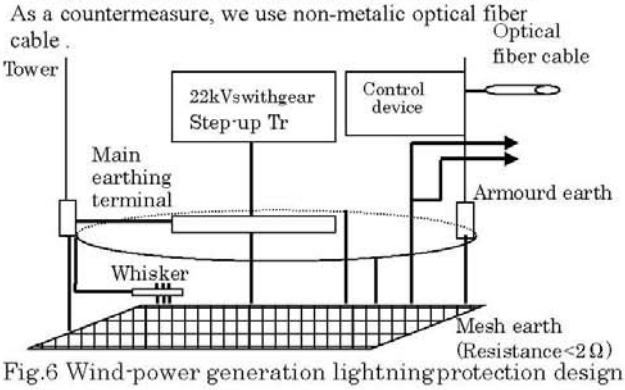

Fig.6 Wind-power generation lightningprotection design

4. Conclusion

We consider that above countermeasures are effective, but it is not complete because the nature of lightning stroke has not been elucidated sufficiently yet, and the number of troubles due to the lightning strokes is still increasing.

We have been conducting the monitoring of lightning strokes and measuring those currents at wind-power generators installed along the Sea of Japan since 2006. We set a goal to analyze these data and find the effective solutions for lightning stroke problems.

Reference:
(1) Wind-power Generation Guideline / Countermeasures for Lightning, March 2008, NEDO
(2) Lightning and Highly Networked Information Society, May 31st, 1999, Institute of Electrical Installation Engineers of Japan