

## THE ICE MONITORING TECHNOLOGY OF TRANSMISSION LINES

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**Abstract:** This paper summarized the current researches and applications of ice and snow monitoring technology and system at home and abroad. And for the actual situation in Hubei province, this paper proposed the application areas and principles of this monitoring system. According to the formation conditions and hazards of ice and snow on transmission lines, this paper main introduced the monitoring technology of ice and snow on transmission lines and the current applications of this technology. Further more, this paper summarized the application features of the monitoring technology and proposed some suggestions for improvement.

### 1. INTRODUCTION

The formation process of icing on conductors is that the supercooling water in air and wet snow drop on the conductors which have a temperature of below 0 °C and then freeze on it [1]. In north China, the climate is dry in winter, so the transmission lines were covered by snow mainly. While, in south China, the ice on conductors is glaze which has a great harm to our power systems.

According to some statistical analysis, in the rain and snow weather, the basic weather conditions of icing on transmission lines as following<sup>[1]</sup>:

- (1) The temperature of air and objects is below 0°C.
- (2) The relative humidity of air is above 85%.
- (3) The wind speed is greater than 1.0m/s and can make the droplets move.

### 2. RESULT AND DISCUSSION

#### A. *The Application Features of Ice Monitoring Technology of Transmission Lines*<sup>[2-4]</sup>

- (1) Accurate and detailed record the icing process at field site.
- (2) Provide early warning function.
- (3) Provide guidance and support decision for de-icing of transmission lines.
- (4) Draw ice distribution map of grid and then provide the basis for design.
- (5) It can reduce the guard time of worker of icing station and the labor intensity of field staff.

#### B. *The Main Problems of Ice Monitoring System/Technology*

- (1) Its Stability needs to be improved.

- (2) Its mechanical transmission parts easily are froze.
- (3) The monitoring parameters are incomplete.
- (4) The communication is not smooth in mountain areas.

#### C. *The Improvement of Ice Monitoring Technology of Transmission Lines*

The parts which need to be further refined and improved in current ice monitoring system as following:

- (1) Further improve the monitoring system itself ability against the severe ice damage/bad weather conditions to make it work well under severe ice disaster and bad weather conditions.
- (2) Rationally plan the monitoring sites of ice monitoring system, and strengthen the monitoring of transmission lines in micro-topography areas, across railway and highway.
- (3) Further improve the monitoring of parameters.

### 3. CONCLUSION

The application of ice monitoring system of transmission lines can replace the expensive ice observe station built in mountain areas. The ice monitoring system has been gradually to the information and intelligence development, it can not only get the information about temperature, dip angle and sag of transmission lines and weather conditions of lines corridor but find the risk of ice damage in the prophase of icing through intelligent control. It is good for elimination of icing accidents in the bud and can raise the level of safe operation of transmission lines in iced areas.

The principle of specific application as following:

- (1) We should selective install ice on-line monitoring devices according to the different altitude in the mountain areas.
- (2) As for the plain areas , it should be mainly consider to install ice on-line monitoring devices on the towers isolate or on higher hillside.
- (3) We should install ice on-line monitoring devices on the 220kV line towers which have been broken down before.

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**Keywords**--icing; transmission lines; ice on-line monitoring; grid; GSM/SMS;

## I. INTRODUCTION

The formation process of icing on conductors is that the supercooling water in air and wet snow drop on the conductors which have a temperature of below 0 °C and then freeze on it [6]. In north China, the climate is dry in winter, so the transmission lines were covered by snow mainly. While, in south China, the ice on conductors is glaze which has a great harm to our power systems.

According to some statistical analysis, in the rain and snow weather, the basic weather conditions of icing on transmission lines as following<sup>[6]</sup>:

- (1) The temperature of air and objects is below 0°C.
- (2) The relative humidity of air is above 85%.
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## II. ICE MONITORING TECHNOLOGY OF TRANSMISSION LINES

At present, the ice monitoring system has been in service in the power network in Hubei and Hunan province, China. If there are some abnormal weather conditions on transmission lines, the system will sends alarming signal to our worker.

The monitoring system consists of three parts: field measurement unit, communication network and expert system background<sup>[1-2],[7]</sup>.

### A. The Ice Monitoring System of Transmission Lines in Shanxi, China

The online monitoring system of icing on transmission lines based on the Global System for Mobile Communications/ Short Messaging Service (GSM/SMS) was developed in October 2005 and operated on Shenyuan I line in February 2006. As of March 1, 2007, this system successfully monitored three times of icing on transmission lines and the most serious is the one during February 28 to March 1, 2007. Figure 1 shows the field icing situation. After getting the alarming signals of monitoring system, operating personnel went to field and deal with the ice on conductors. They found that the ice is mainly the snow [7].



(a) Icing on tower



(a) Icing on conductor

Figure 1. The picture of field icing on #109 tower of Shenyuan I line (took in March 2007)

### B. The Ice Monitoring System of Transmission Lines in Hunan, China

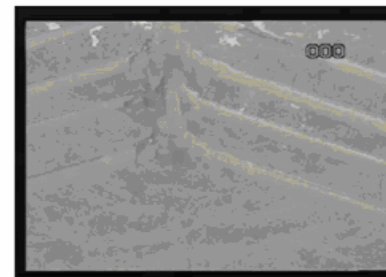


Figure 2. The icing on #65 tower of Heyun line in Hunan

The Hunan provincial electric power corporation has installed 68 field icing monitoring devices on fifteen 500kV lines (22 towers) and thirty-four 220kV lines (46 towers) in 14 regions. The monitoring network of disaster of Hunan grid has been constructed initially. In the system, data was

collected by a embedded sensors installed on tower and then sent to Internet through GPRS (CDMA) network. The data come from every tower was collected in dedicated central server of scheduling department through Public information network<sup>[1-2]</sup>.

In the icing disaster in 2008, especially during the prophase of icing on conductors, the Hunan provincial electric power corporation got the information about ice thickness, temperature, humidity, wind direction, wind speed, rainfall, etc. and their changes in time

### C. The Ice Monitoring System of Ttransmission Lines in Hubei, China

Using high-performance camera, low power consumption platform and special sensors, the live video images of transmission lines were captured and sent to our scheduling department through GPRS/CDMA network [1].

The ice monitoring results of Wanlong II line during January 17 to 18, 2007, were shown in Fig.3.

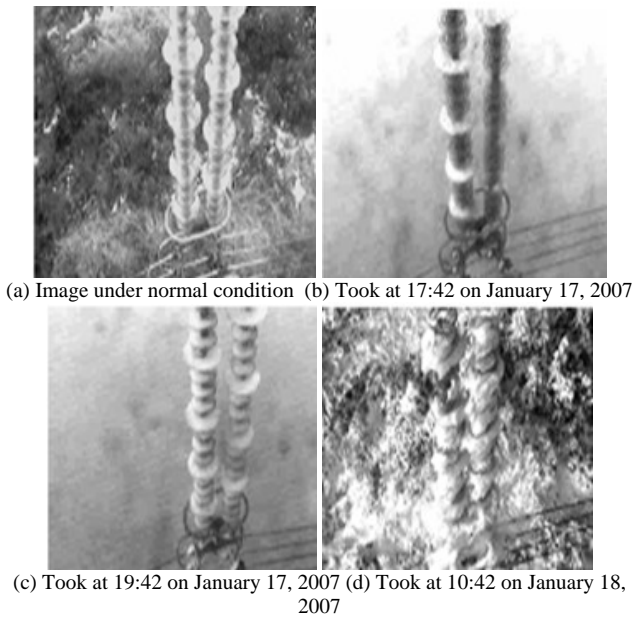


Figure 3. The icing process of line insulators

The icing monitoring result of insulator strings on the #560 tower of Wanlong II line on January 15, 2008 was shown in Fig.4.

### D. The Ice Monitoring System of Central China Power Grid Company Limited and Hubei EHV Transmission and Substation Company

The ice online monitoring system of transmission lines developed by Central China Power Grid Company Limited has passed the technical appraisal organized by Department of Science and Technology of Hubei Province on December 17, 2006. At present, this monitoring system has been applied in many projects of Hubei EHV Transmission and Substation Company<sup>[1][5]</sup>.

### E. The Anti-icing Warning System of South China Grid

In April 2008, the anti-icing warning system of South

China Grid enter the implementation phase. The first demonstration system which consists of 30 monitoring points was constructed in Guizhou grid.

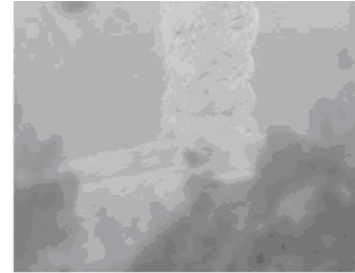


Figure 4. the icing picture of insulator string

### F. The Studies on Icing of Transmission Lines in Canada

After 1998, the water and power authority in Quebec, Canada constructed icing test station to carry the test studies on icing and ice monitoring devices. They use conventional climate models to simulate and predict icing. They try to use the data of conventional weather forecasting system combined with icing models to generate the icing zones chart and then forecast the zones which will occur icing disaster<sup>[9]</sup>.

## III. THE APPLICATION FEATURES AND IMPROVEMENTS OF ICE MONITORING TECHNOLOGY/SYSTEM OF TRANSMISSION LINES

### A. The Application Features of Ice Monitoring Technology of Transmission Lines

- (1) Accurate and detailed record the icing process at field site.
- (2) Provide early warning function.
- (3) Provide guidance and support decision for de-icing of transmission lines.
- (4) Draw ice distribution map of grid and then provide the basis for design.
- (5) It can reduce the guard time of worker of icing station and the labor intensity of field staff.

### B. The Main Problems of Ice Monitoring System/Technology

- (1) Its Stability needs to be improved.
- (2) Its mechanical transmission parts easily are froze.
- (3) The monitoring parameters are incomplete.
- (4) The communication is not smooth in mountain areas.

### C. The Improvement of Ice Monitoring Technology of Transmission Lines

The parts which need to be further refined and improved in current ice monitoring system as following:

(1) Further improve the monitoring system itself ability against the severe ice damage/bad weather conditions to make it work well under severe ice disaster and bad weather conditions.

(2) Rationally plan the monitoring sites of ice monitoring system, and strengthen the monitoring of transmission lines in micro-topography areas, across railway and highway.

(3) Further improve the monitoring of parameters.

#### IV. INTEGRATED DESIGN OF ICE MONITORING SYSTEM OF TRANSMISSION LINE

##### A. Parameter Design of Ice Online Monitoring System of Transmission Lines

a) Wires (include consist of conductor, ground wire and OPGW) [3-4][9].

The main characteristic parameters are the amount of ice, the amplitude and frequency of conductor galloping, windage yaw angle and conductor temperature.

b) Insulator strings.

The main characteristic parameters are leakage current and windage yaw angle, etc.

c) Towers (include steel towers and combined angle steel towers).

The main characteristic parameters are tower tilt and tower tension.

d) Meteorology and environment (include weather conditions and corridor conditions) [3-4].

The main characteristic parameters are wind speed, wind direction, ambient temperature, humidity, rainfall, air pressure and so on.

##### B. The Ice Online Monitoring Devices of Transmission Lines

The ice online monitoring devices mainly include: the ice monitoring devices of conductors, the galloping monitoring devices of conductors, the swaying monitoring devices of conductors and insulator strings, the temperature monitoring devices of conductors, the leakage current monitoring devices, the tilt monitoring devices of towers, the tension monitoring devices of towers, weather monitoring devices and video monitoring devices of transmission lines.

#### V. CONCLUSIONS

The application of ice monitoring system of transmission lines can replace the expensive ice observe station built in mountain areas. It will save a lot of manpower and financial resources. The ice monitoring system has been gradually to the information and intelligence development, it can not only get the information about temperature, dip angle and sag of transmission lines and weather conditions of lines corridor but find the risk of ice damage in the prophase of

icing through intelligent control. It provides the early warming information for operational departments. It is good for elimination of icing accidents in the bud and can raise the level of safe operation of transmission lines in iced areas.

The comprehensive collected and long-term accumulated information about the temperature, dip angle and sag of transmission lines and the weather conditions can provide basic data for the design, operation and maintenance and economic dispatching of power network. The video monitoring of transmission lines corridor could be used to prevent external damage to power facilities.

It is an effective means of reducing disaster to construct and refine the ice monitoring system of transmission lines because that is more realistic than using the traditional meteorological data.

It is very significant for the accurate and efficient implementation of disaster prevention dispatching to develop the icing early warning and monitoring system of transmission lines, to draw the accurate icing areas map, to develop the operating rules and standards of transmission lines under icing and snow conditions and to strengthen the emergency measures of anti-icing.

Considering the effectiveness of ice monitoring and the icing areas in Hubei, this paper recommends to install the ice online monitoring devices in the En-Yi-Jing-Jing grid of Hubei province and in the area of Xianning. The principle of specific application as following:

(1) We should selective install ice on-line monitoring devices according to the different altitude in the mountain areas.

(2) As for the plain areas , it should be mainly consider to install ice on-line monitoring devices on the towers isolate or on higher hillside.

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