ANALYSIS OF HUNAN POWER GRID ICE DISASTER IN 2008 AND RELATED SERIES ANTI-ICING TECHNOLOGY RESEARCH

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***Abstract*: At the beginning of 2008, the extreme climate phenomena caused by global warming, ice disaster process, and influence on Hunan power grid were systematically presented and analyzed. Transmission and transformer equipment loses were statistical analyzed.**

On the analysis of the 2008 Hunan grid ice plague of reason, process and solutions, this paper carried out a series of anti-icing technology research based on actual demand. Firstly, according to the actual requirement of remote monitoring, an ice monitoring system has been developed. Then, by using high-voltage high-power electronic technology, multi-grade voltage, movable and fixed AC and DC melting ice devices have been studied and manufactured for Hunan power transmission line ice melting.

1. INTRODUCTION

From January 11, 2008, with low temperature and rainy weather, a large number of 220kV and 500kV power lines were iced at cities of Changde, Yiyang, Xiangtan, Loudi, Changsha, Yueyang, Shaoyang, Huaihua. The maximum thickness of ice was more than 70~80mm. With respect to the duration, range and thickness of ice, the ice disaster is the most severe one since 1954.

2. RESULTS AND DISCUSSION

The ice disaster process is divided into five Phases: primary phase, developing phase, durative phase, climactic phase and falling down phase. Each phase is represented in detail in this paper.

The damage by ice disaster is listed thoroughly.

Table 1: Collapsed Towers Statistics of 500Kv Level

Serial number	Power line	Sum of collapsed towers
1	Chuanxing line	52
2	Jiangcheng line	40
3	Minhe line I	19
4	Xiangyun line	13
5	Gangai line	13
6	Aihe line	12
7	Wumin line	11
8	Heyun line	11
9	Fusha line I	4
10	Huasha line	3
11	Sanpai line	3
12	Heyun line	1

On the analysis of the 2008 Hunan grid ice plague of reason, process and solutions, this paper carried out a series of anti-icing technology research. Firstly, an ice monitoring system has been developed. The system is made up of five parts: data acquisition device of field MCU, embedded system, server system, client software and web data publishing system. Then, by using high-voltage high-power electronic technology, multi-grade voltage, movable and fixed, AC and DC melting ice devices have been studied and manufactured for Hunan power transmission line ice melting.

3. Conclusion

Ice disaster resistance of power lines increased by the ordeal of ice disaster. A variety of equipments have been developed. We should gain experience from the disaster and establish appropriate anti-disaster procedures, which can contribute to the correct operation of power grids.

4. REFERENCES

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Abstract: **At the beginning of 2008, the extreme climate phenomena caused by global warming, ice disaster process, and influence on Hunan power grid were systematically presented and analyzed. Transmission and transformer equipment loses were statistical analyzed.**

On the analysis of the 2008 Hunan grid ice plague of reason, process and solutions, this paper carried out a series of anti-icing technology research based on actual demand. Firstly, according to the actual requirement of remote monitoring, an ice monitoring system has been developed. Then, by using high-voltage high-power electronic technology, multi-grade voltage, movable and fixed AC and DC melting ice devices have been studied and manufactured for Hunan power transmission line ice melting.

Keywords: Ice Disaster, Hunan Power Grid in 2008, Anti-icing Technology, Ice monitoring system, Ice Melting.

Ⅰ. INTRODUCTION

Hunan province is located at the middle-down area of Changjiang river, south of Dongting lake, and surrounded by mountains on three sides. Foothill, hummock and plain are the main landforms in the middle area of Hunan. The landforms are benefit to the north cool air coming directly. At the boundary of Chenzhou City and Guangdong province, the "Nanling stationary front" forms, where ice covering intends to be developed on power lines when cooling water is not steady[1].

From January 11, 2008, with low temperature and rainy weather, a large number of 220kV and 500kV power lines were iced at cities of Changde, Yiyang, Xiangtan, Loudi, Changsha, Yueyang, Shaoyang, Huaihua. The maximum thickness of ice was more than 70~80mm. With respect to the duration, range and thickness of ice, the ice disaster is the most severe one since 1954[2].

Ⅱ. PROCESS OF THE ICE STORM

A. *The First Phase: primary phase (Jan.11 to Jan.19)*

There was a temperature falling process from north to south in Hunan with cool air moving to south. Rain, hail and snowfall happened subsequently. A snow storm occurred in the west Hunan, middle Hunan and north Hunan on Jan.14. There were 7 times of AC short de-icing events and 20 times of trips in 220kV power lines. There were not any trips of 500kV initially. On Jan.18, structure distortion happened at tower NO.47 of Aixiang line, and the ground line of tower NO.132~NO.133 of Tuanda line broke apart. Ice covering was in an initial developmental phase. The main structure of Hunan power grid did not affected greatly and the ability of power supply was maintained at a normal operation level.

B. *The second phase: developing phase (Jan.20 to Jan.23)*

Heavy snow started in the local area of north Hunan and the cold snow rain weather continued. In this phase icing was developed quickly, except Changde city and Zhangjiajie city. The trip frequency of the 500kV power lines increased up to 36 times. The structure of the 500kV power grid was damaged severely. Trip frequency of the 220kV power lines increased up to 36 times, however there were only 15 power lines of 220kV, which were not in operation as reserves.

On Jan. 20, Fuxing power station, Fusha line I, Fusha line II, Fuai line I and Fuai line II stopped operation. The channel of "west power to east" was interrupted, which was designed to supply power to the Chang-zhu-tan load center.

C. *The third phase: durative phase (Jan.24 to Jan.26)*

Ice covering became severe by the influence of the southern branch and cool air, continuance of the cold and snow weather, and precipitation. Icing continued to develop in all the region of Hunan province. A large number of trips occurred at the 220kV power lines with 159 times of trip. Until Jan. 26, there were 36 pieces of lines, which quitted operation. The structure of the power grid was affected greatly. As a result, the divided power grid ran separately and the relation between the separated grids was weak. Unavoidably, the control strategy of the Hunan 220kV power grid was divisional control in separated regional grids in order to achieve balanced power distribution.

D. *The fourth phase: climactic phase (Jan.27 to Jan.31)*

On Jan. 27, there were flurry and hail at the main region, as well as a medium to heavy snow at the local area under the influence of air flow of upper air and cool air of ground. Subsequently, a snow storm started on Jan. 28. Then, temperature came to rise in the middle and north areas of Hunan on Jan. 29. Ice of power line melted naturally due to the temperature rise. Consequently, the second large-scale wave of trips happened in the 220kV and 500kV power lines.

The worst conditions during the disaster were on Jan. 29. During this day, 86 pieces of the 220kV power line and 15 pieces of the 500kV power line were tripped. Thirty one 220kV power stations and four 500kV power stations stopped running completely. The whole power grids of Hengyang, Chenzhou and Yongzhou stopped operation. The power grid of Xiangnan was separated from the main power grid of Hunan.

E. *The fifth phase: falling down phase (Feb.1 toFeb.8)*

With the influence of high air low branch, freezing rain of Xiangnan gradually stopped. Ice on the power line in Xiangbei melted. The disastrous condition of Xiangzhong was relieved. From Feb.4, temperature start to rise and the frost weather gradually disappeared. The power grid immediately started to repair the faults occurred during the disaster. On Feb. 1, the power grid of Hengyang was connected to the main power grid. On Feb. 5, the power grid of Chenzhou was reconnected with the main power grid.

Ш. EFFECT OF ICE DISASTER ON POWER GRID

A. *Flashover trips*

1) Flashover trips of the 500kV power lines in the period of icing: From Jan. 13 to Feb. 4, there were 126 trips in 29 pieces of 500kV power lines, with 19 trips in the Paichang line, 12 trips in the Jiangfu line II. There were more than 5 trips in the Minhe line I, Fusha line II, Fuai line II, Xingyun line, Gangfu line, Wumin line, and Xiangyun line I respectively.

2) Flashover trips of the 220kV power lines in this disaster: From Jan.13 to Feb.4, there were 683 trips occurred in the 220kV power lines.

B. *Tower collapse and wire breakage*

There were 182 collapsed towers and 68 transformative towers in 500kV power lines. 159 pieces of conductors and 322 pieces of ground wire were either broken or damaged. Insulators dropped at 284 spots.

There were 633 collapsed towers and 203 transformative towers in 220kV power lines. 241pieces of conductors and 432 pieces of ground wire were either broken or damaged. Insulators dropped at 36 spots.

In 110kV power lines, there were 1427 collapsed towers and 421 transformative towers. 646 pieces of conductors and 1017 pieces of ground wire were broken or damaged. Insulators dropped at 30 spots.

In 35kV power lines, there were 1064 collapsed towers and 1005 transformative towers. 1369 pieces of conductors and 296 pieces of ground wire were broken or damaged. Insulators dropped at 89 spots.

In the 10kV distribution network, 636036 towers collapsed and 47898 pieces of conductors were broken. There were 3380 damaged distribution transformers. In the low voltage power system, there were 330450 collapsed towers and 367673 conductors damaged.

Table 2: Collapsed Towers Statistics of 500Kv Level

Serial number	Power line	Sum of collapsed towers
1	Chuanxing line	52
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Fig.1: #390 collapsed tower of 500 kV Wumin line

C. *Transformer dandification*

In total, the 220kV Yutan #1 transformer and the oil pump and contactor of Chengqianling #1 transformer were damaged. 35 kV bushings of Yizhang #1、#2 of 110kV transformers were destroyed [4].

Ⅳ RESEARCH OF ANTI-ICING TECHNOLOGY

A. *Ice monitoring system of power transmission lines*

In order to monitor the ice-covering and meteorological of power transmission lines more conveniently ,the ice monitoring system based on comprehensive analysis of ice-covering characteristic have been developed in Hunan electric power test and research institute[5].

An embedded system seated on towers is the data platform of ice monitoring system. The system connects with Internet through GPRS (CDMA) net. The data platform focus the data on special server installed on ice monitoring center of Hunan Power Grid.The structure of system is shown in Figure2.

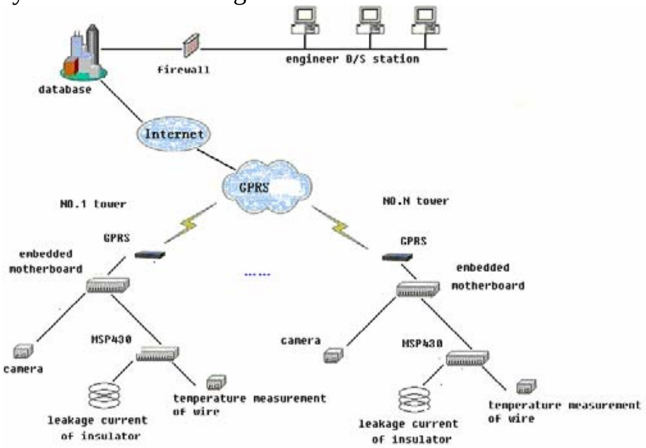

Fig.2 structure of system

The system is made up of five parts:

1) Data acquisition device of field MCU. It can implement data acquisition function and sample 32 discrete data points in one cycle**.** The type of system's CPU is MPS430.The acquainted data includes leakage current, CO content, meteorological parameters and so on**.**

2) Embedded system.Arm7 is the kernel of embedded system .The main function of system includes collecting and sending ice images, transmitting data collected by MCU and server monitoring order**.**

3) Server system. Server system includes server program and alarm scheduling program. It is used mainly for managing message of embedded system and transmitting alarm scheduling program and control message of client. Alarm scheduling program's function mainly includes collecting timing data, automatic diagnosis of ice-covering thickness and saving the data to database.

4) Client software. The function of client software mainly includes control of camera and rotational station, real-time data acquisition. It is operated by connecting with embedded system through server-side software.

5) Web data publishing system. The function of web data publishing system includes displaying real-time data, searching historical data, searching historical trend and displaying image. It is convenient for working staff to browse monitoring data with browser. Data can be picked up from database by the web data publishing system **6]**.

B. *A new type of AC and DC De—Icer*

1) Regulative Capacitor Series—Wound Compensate AC De—Icer

Regulative Capacitor Series—Wound Compensate AC De—Icer is mainly made of capacitance (Figure 3), it is applicable to 220kv lines whose length range is 0～40 km. The structure of devices is three-phase type, per phase is made up of 3 capacitorbanks and per capacitorbank is composed of 10 capacitors by parallel connection. By the way of series parallel of 3 capacitorbanks and choosing the parallel number of per capacitorbank, capacitive reactance can be regulated smartly. Technology parameters of devices are as follows:

Normal rated current: 1600A;

Normal rated voltage: 15kV

Normal rated frequency: 50HZ

Normal phase number: three

Normal rated capacity: 26.1Mvar

Normal insulation and withstand voltage level to groud,1 min power frequency tolerance voltage**:** >63 kV. Impact tolerance voltage**:** >1l2.5kV

Normal line length of melting ice: 0～40 km 220kv lines and below

Fig.3 Regulative Capacitor Series**—**Wound Compensate AC De—Icer

2) Mobile DC De-Icer

Diode is used as the rectifier element of Mobile DC De-Icer which is connected by 6**-**Pulse Wave bridge rectifier**.** In the case of without voltage adjusting, the melting ice devices can meet the needs of 50～150 km power lines melting ice by the way of Six-pulse converter bridge rectifier and reasonable adjustment of transmission line connection mode [8]. The appearance of devices is shown in Figure 4. The main technology parameters of devices are as follows:

Normal rated power: 25MW

Normal rated output DC: 2000A

Normal rated output DC voltage: 12 500 V

Normal rated input voltage: 10 500V

Normal line length of melting ice: 50～150 km

Fig.4 Mobile DC De-Icer

3) Fixed DC De—Icer

Fixed DC De—Ice is made up of rectifier transformer and 12-pulse wave controllable rectifier (Figure 5)**.** The output dc voltage of devices can be started to regulate from **0**V. it is applicable to lines whose length range is 0～40 km. Technology parameters of devices is as follows:

rated power: 4.2 MW
rated output DC: l 400A
rated output DC voltage: 3 000 V

rated input voltage: 10 500V

line length of melting ice: 0～40 km

Fig.5 Fixed DC De—Icing Device

Ⅴ. CONCLUSION

At the beginning of 2008, the worst ice disaster since 1954 stroke the Hunan power grid. By the hard work conducted by the power department, the grid restored normal power supply. Ice disaster resistance of power lines increased by the ordeal of ice disaster. A variety of equipments have been developed. We should gain experience from the disaster and establish appropriate anti-disaster procedures, which can contribute to the correct operation of power grids.

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