Summarization of On-line Icing-monitoring Methods of Transmission Lines

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Abstract: The icing condition of overhead transmission line is greatly harmful to the safety operation of the power system. At present, the monitoring methods of transmission line is mainly to observed and measured manually on-site in China, and it urgently needs a more reliable transmission line monitoring method. In this paper, the on-line icing monitoring system of transmission lines has been studied, and the structure of on-line monitoring system has been described, what mainly focuses on are variety of methods of on-line icing monitoring developed recently, such as: gravimetric method, dip - sag relations method, image method, and the theoretical basis and application conditions. Also, it compared their advantages and disadvantages, what is more, the development prospects of on-line icing-monitoring technology was discussed.

1. INTRODUCTION

At present, the monitoring methods of transmission line is mainly observed and measured manually on-site in China. Transmission lines with icing are influenced by the micro-meteorology, micro-topography and other factors, and the icing disasters often occur in sparsely inhabited and inaccessible areas, in those areas, there are difficulties to inspect the lines manually. Therefore, it urgently needs a reliable on-line monitoring system of transmission lines that can accurately and timely understanding the site conditions, assess the transmission lines icing situation and warn, then giving guidance to take appropriate preventive measures for the relevant lines, which can effectively prevent the icing transmission lines break, insulators fitting loss and other accident occurrence, it has great significance to improve the power grid safe and reliable operation.

2. PROSPECT

The monitoring system based on weighing method still will be the future direction of development.

With the development of fiber optical sensing technology, data collected will be more reliable, and the system will be more anti-jamming.

As is quite complex relationship between ice quality and wire dip angle, temperature, an accurate calculation model remain require a lot of effort.

With the smart grid proposal and its technology developing, comprehensive analysis and integration of application platform development is the future. Internet of things apply in on-line monitoring is a hot development direction in the future.

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Abstract- The icing condition of overhead transmission line is greatly harmful to the safety operation of the power system. At present, the monitoring methods of transmission line is mainly to observed and measured manually on-site in China, and it urgently needs a more reliable transmission line monitoring method. In this paper, the on-line icing monitoring system of transmission lines has been studied, and the structure of on-line monitoring system has been described, what mainly focuses on are variety of methods of on-line icing monitoring developed recently, such as: gravimetric method, dip - sag relations method, image method, and the theoretical basis and application conditions. Also, it compared their advantages and disadvantages, what is more, the development prospects of on-line icing-monitoring technology was discussed.

Keywords- transmission lines icing , on-line icing-monitoring , weighing method,dip angle-sag relations act , image method.

I. INTRODUCTION

China is one of the most affected areas by icing of transmission lines because of the diversity of geography and climate.In the past 30 years, large-scale icing disasters frequently occur across the country [1-3].In January of 2008, most parts of southern China suffered a rare constant low temperature, sleet and extreme freezing weather condition, which lead to a large area of ice covering on transmission lines, many transmission line towers collapsed for intolerable load, the power facilities were unprecedented destructed, seriously affecting the normal grid operation.

At present, the monitoring methods of transmission line is mainly observed and measured manually on-site in China. Transmission lines with icing are influenced by the micro-meteorology, micro-topography and other factors, and the icing disasters often occur in sparsely inhabited and inaccessible areas, in those areas, there are difficulties to inspect the lines manually. Therefore, it urgently needs a reliable on-line monitoring system of transmission lines that can accurately and timely understanding the site conditions, assess the transmission lines icing situation and warn, then giving guidance to take appropriate preventive measures for the relevant lines, which can effectively prevent the icing transmission lines break, insulators fitting loss and other accident occurrence, it has great significance to improve the power grid safe and reliable operation[4-15].

II. ON-LINE ICING MONITORING SYSTEM

On-line icing monitoring system of transmission lines is mainly composed of line monitoring terminal, center monitor master station and expert system[6-13]. Topology of the system is shown in Figure1.

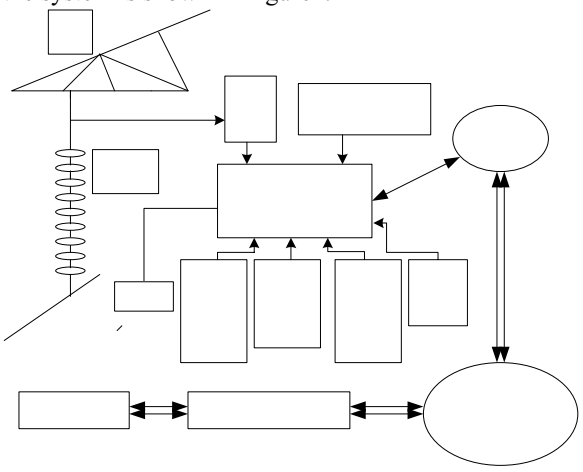

Figure 1 topology of system

Line monitoring terminal consists of various types of sensors, including pressure sensors, angular displacement sensors, temperature and humidity sensors, wind speed sensors, wind direction sensors and solar radiation sensors. These sensors were installed between iron tower and insulator strings. The monitoring terminal to complete the iron tower and transmission line comprehensive tension, uneven tension difference, insulator wind declination angle, iron tower tilt angle and meteorological parameters (including temperature , humidity, wind speed, wind direction, solar radiation intensity) and other information collection timely or on real-time. By GSM / GPRS and other mobile communication network or fiber-optic to transmit data between line monitoring terminal and center monitor master station. After receiving the collected data by center monitor master station, according to expert system software, using the related icing theoretical model to analyze icing conditions of the monitored transmission lines. The center monitor master station can set the parameters of monitoring terminal (such as the sampling

time interval, the extension system time, real-time data request etc).The monitoring terminal using solar energy and battery or getting energy from transmission line by induction to work[6-18].

The functions of on-line monitoring system includes: the on-line monitoring equivalent ice thickness of transmission; micro-meteorological data monitoring; iron tower force condition monitoring and analysis; line vibration and its frequency monitoring; wind partial state analysis; video on-line monitoring[6-24].

Problem: The accuracy of data collection problems; interference problems; the high costs of monitoring systems; unified communication protocol issues; the blind area of mobile signal; power supply of the monitoring terminal; incomplete monitoring parameter; incomplete database; model is not precise enough; the protection of monitoring terminal and so on[6-24].

Solution：Strengthen the research on fiber optic sensing technology; unified communication protocol; establish integrated platform for early warming;Improve the efficiency of the get energy from transmission line by induction, enhance anti-interference ability of take energy device; use low-power monitoring terminal; monitoring terminal layout optimization; use more realistic and considered multi-factor model and so on[4-24].

III. ON-LINE ICING MONITORING TECHNOLOGY OF TRANSMISSION LINES ICING

The on-line icing monitoring methods of transmission lines basically has weighing method [5-24], angle-sag relations act [4-18] and image method [11-17].

A. Weighing Method

This method is the most direct, reliable and minimum error of international current method[5-16].

Principle: it replaces the ball head hanging ring with tension sensor, and direct measure the wire weight within a vertical span. Using wind speed, wind direction and angular displacement sensor to calculate the drag coefficient and tilt component of insulator strings, then by exclusion method, eventually to got the ice weight, and caculate equivalent ice thickness by 0.9 g/cm^3 density conversion[5-14].

Advantages:This method can fully get meteorological conditions along transmission line and comprehensive collection and accumulated meteorological data. The icing monitoring device using weighing method also has good expansibility function. Dual-axis tilt sensor can be installed to monitor the vertical pressure of tower, the imbalance vertical tension, wire wind declination angle and iron tower tilt angle and so on[4-14].

Shortcomings: Now resistance strain sensor is widely used. The sensor produced simple and cheap, but it is susceptible to environmental effects, bridge balance is difficult, nonlinearity, susceptible to electromagnetic interference, cannot long-term stable operation and other important issues[4-14].

Solution: Fiber grating weighing sensor has long life, little nonlinear error if not in harsh environment and it overcome the shortcomings of being easily affected by electromagnetic interference defects of traditional weighing transducers. At present this method is still in theoretical study and is seldom used in practical projects[17-24].

B. Angle-sag Relations Act

The most obvious phenomenon is the increase in the line sag when transmission lines icing.

Principle: Combine the collected wire dip angle, sag and other parameters with state equation of transmission line, line parameters and meteorological environmental parameters; calculate the ice weight and average ice thickness and other parameters on the line.

Advantages: The state equation can be applied to simplify the irregular transmission line calculations.

Shortcomings: this program calculated ice thickness results is the average value within a span, cannot reflect the specific distribution of ice and in the case of uneven transmission line icing use state equation to calculate will make much error. Line sag and dip angle change with the ice thickness. Because of the change of dip angle will not great. So it needs a high-resolution measuring device to estimate the line icing situation. Now, it usually use the transmission line as a flexible cable in calculation, but the stiffness of wire would change in the process of icing. The key problem of this method is the wire sag and temperature curves are affected by many factors, even the slightest error, ice quality will be a big difference.

Solution: Use model that more realistic and considered multi-factor includes multi-tower, wire stiffness, wind load, conductor galloping and vibration factors.

C. Image Method

Principle: By means of installing image monitoring devices along pole tower , timing monitoring wires, insulator, tower, lines corridor of cladding ice conditions, using GSM/GPRS etc wireless data transmission system etc transmits pictures to the monitoring center, monitoring image can real-time view or playback, so as to achieve transmission line round-the-clock monitoring . Observing wires and insulator cladding ice formation and development situation can give some references. It utilizes mathematical method of differential equation to calculate cladding ice area with wire inherent geometric dimensions, then the conversion to equivalent cladding ice thickness, to know the severity of the cladding ice, in order to take corrective action[8-14].

Advantages: Image method is simple and intuitive to observe various monitoring area cladding ice conditions.

Shortcomings: Image method can only acquire cladding ice condition near around, and the collection information is limited; If ice cover is serious uneven, monitoring results have a deep deviation with the actual situation, so it cannot really reflect the equivalent of cladding ice conditions; In severe snow, camera may be covered, causing the whole monitoring system paralyzed, and on-site video only have

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fixed number of points, so it can not be freely controlled, solar and battery-powered way may cause power shortage[7-13].

Solution: Multiple cameras can obtain cladding ice conditions in different parts, Using low energy consumption of monitoring system and induction can improve the power supply problems, but it need anti-interference ability[4-16].

Because it can not reflect the transmission line integral cladding ice condition, the monitoring technology also needs further research.

IV. PROSPECT

After years of researchers' persistent research and practice, overhead transmission line icing on-line monitoring technology has developed very quickly.

Because harsh operating environment of monitoring system, electromagnetic interference is more, need to continuously improve the reliability of the collected data.

The monitoring system based on weighing method still will be the future direction of development.

The technology of get energy from transmission line by induction need further study.

With the development of fiber optical sensing technology, data collected will be more reliable, and the system will be more anti-jamming.

The development of wireless signal transmission technology and signal processing technology will greatly improve the reliability of the results of monitoring system operation.

As is quite complex relationship between ice quality and wire dip angle, temperature, an accurate calculation model remain require a lot of effort.

With the smart grid proposal and its technology developing, comprehensive analysis and integration of application platform development is the future. Internet of things apply in on-line monitoring is a hot development direction in the future.

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