Thinking and Some Suggestions about Ice Coating Disaster in Power Networks

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***Abstract*—From January 2008 to February 2008, Southern China encountered rare ice coating in power networks, which leads to many transmission line breaking and transmission tower falling down. The stable operation of power systems and reliable power supply are faced with huge challenges. In this paper, effect and characteristics of ice coating disaster in power system is analyzed, and the experiences and lesions are summarized. At last, some suggestions are presented, such as the key problem building ice coating disaster defense system, ice coating monitoring and prediction, ice coating safe grade real-time assessment in power system and ice coating catastrophe emergency disposal.**

Keywords- ice coating; catastrophe; defense system; emergency disposal

I. INTRODUCTION

In January, 2008, Central China, East China and Southwest China were hit by disaster freezing weather.Especially, Hunan Province, Anhui Province, Guizhou Province and Jiangxi Province encountered the worst ice coating in the last 50 years, which led to the severe ice coating of the transmission line , transmission tower and other power equipment, more than 36,000 power lines of 10kV and above breaking, more than 2,000 substation of 35kV and above outage. Which brought enormous influence of transportation, energy supply and the people' life eventually.

In recent years, ice coating accidents in power system frequently happened in China and the stable operation of power systems and reliable power supply were faced with huge challenges, which brought significant economic losses to the social [1 ~ 3].So, it is very important that how to reduce the effect of ice coating to the power grid effectively. Thinking and some suggestions about ice coating disaster in power system are presented by the paper according to power grid construction and grid planning, de-icing technology, emergency and recovery control, optimizing maintenance scheduling, display platform and defect prediction system in power system, emergency measures to ice coating and the strengthen of the crisis awareness and so on. Some suggestions are presented, such as the key problem building ice coating disaster defense system, ice coating monitoring and prediction, ice coating safe grade real-time assessment and ice coating catastrophe emergency disposal in power system.

II. INFLUENCE OF ICE COATING CATASTROPHE IN POWER SYSTEME

There are many accidents for ice coating disaster in power system in China [1 ~ 4]. In the view of these accidents, we can get these conclusion that ice coating will cause serious influence on power systems, which is mainly manifested in several aspects: (1) During the early of ice coating or ice melting period, transmission equipment ice flash frequently happen, which will cause line trip, insulator crack and other accidents. (2) Inequable ice-coating on a line or ice shedding will make wires produce oscillation and dancing, wire and hardware wear, tower deformation, and also lead to line between electric clearance decreased, finally, wire discharge will cause burns and other accidents. (3) In the serious ice coating area, isolating switch static contactor and drive system in the substation should be frozen jammed, unable to normal points off operation, and will cause isolating switch accident, even can cause bus-bar outage or substation outage. (4) Ice thickness more than design standards will cause serious accident such as line breaking and pour tower, and result in local electric network blackout and large area blackout.

III. THINKING ABOUT ICE COATING DISASTER

Overview of recent years major ice coating accident happened, have the following characteristics: (1) Ice coating accident lasted for a long time, and was growing at a faster pace, covering large area and resulted in tremendous economic loss. (2) Mechanical failure and electrical failure coexist in ice coating accident. (3) Ice coating accident occurs in the cold and warm air of junction area. Combine all previous grid ice coating accident, come to the enlightenment.

A. Power grid planning and grid construction

Grid ice coating cause line disconnection and pour tower, the direct reason for accidents is that cladding ice thickness was far beyond design standards, such as January 2008, Hunan, Guizhou grid lines actual cladding ice thickness most than 30mm, many regions even more than 50 above (generally, Midwest China line cladding ice design standards are 10mm, individual location is 15mm).

Serious grid cladding ice accident gave us an important enlightenment: grid planning should properly increase

design criteria. However, transmission equipment design standards should be increased to what level? This is also a problem worthy of reflection. To ensure that serious grid cladding ice small probability accident system integrity will require high grid investment, and emphasize the power system planning of economy and may increase the probability of grid accident. Therefore, it is the vital significance that how to coordinate the power grid planning in the reliability and economical efficiency. To achieve improved design standards should be made to the appropriate. To master ice plagues rules and characteristics, and to extract ice disaster accident probability value in grid planning, area of ice disaster happening easily should be a lot of observation and comprehensive assessment.

This rare ice disaster make grid structure severely damaged and system split, which give us a wake-up call, adhere to the power decentralized access by end system principle, adhere to the renewable energy and distribution of power construction, special attention should be paid to the coordinated development of power sources and power networks, optimize the power construction in order to improve the resistance to natural disasters ability. After grid ice coating accident, local power grid collapse, caused power serious shortage of situation, some areas loss black start ability, resulting in huge economic losses. Therefore, reasonable configuration of black-start power supply can not be ignored in power generation except insist on renewable energy and distribution of power construction, it should be considered to energy storage device new technology research, such as fuel cell, micro turbine, solar battery energy storage device etc.

B. Operation and Dispatching Mechanism in Power System

Although our country's grid ice coating accidents bring great influence, but didn't bring widespread blackouts accidents, and local grid also gradually recover operation in the short term, it will benefit from China power grid "unified dispatching, classification management" principle. Our country should strictly adhere to the "unified dispatch and classified management, achieves the power grid coordinate operation and control. To ensure the timely recovery after the accident and prevent accident further expanded, unified deployment "three defensive lines" is necessary.

C. Removing ice Technology and Icing Monitoring Technology Research

Ice coating formation process is usually characterized "generation – development – keeping – ablation - development – re-keeping - redevelopment" cycle, the characteristic is alternant development and continuous increasing. If ice condition was monitored in real time and corresponding measures were adopt to remove ice during the line ice coating, it can be avoid grid ice coating accident further expansion. Therefore, it has an important meaning that research on removing ice technology and ice monitoring technology is strengthened, both at home and abroad, many methods of removing ice can be classified into the following four categories: (1) thermal removing ice method, (2) machinery removing ice method, (3) passive removing ice method, (4) other new removing ice method, such as electronic freezing technique, corona discharge technology, ultrasonic technology, laser technology, etc. Each removing ice methods has advantages and disadvantages. Heat removing ice method using human and dynamic routing is high energy costs. Mechanical removing ice method is little energy consumption and low prices, but the operation is difficulty and safety performance is poor. Passive removing ice method is simple, but it may cause wire jump accidents. All localities should be based on its own features to select proper removing ice method.

Previous ice coating monitoring is mainly by artificial line-tracking, and it requires a lot of material and financial, and it also cannot be real time observed situation of ice coating line, the effect is poor. For real-time monitoring line ice coating, eliminating ice coating influence, improving the power equipment reliability, real-time monitoring line ice coating technology research should be strengthened. At present main techniques for real-time ice coating is line image real-time monitoring, infrared instrument observation technology, mobile communications (GSM) data real-time transmission based on the global system, combining the expert knowledge analysis ice coating[5-6].

D. Grid EmergencyControl and Restore Control

There are many unpredictable factors in power system, it is impossible to completely prevent accident of power network. Emergency control in power system is feed-forward control to prevent the system instability or massive blackout after the accident. Appropriate and fast the emergency control can prevent large area blackout and reduce the power outage losses. In China, power grid are gradually formed the national interconnected pattern and power grid operation conditions are ever more complex. However, grid ice coating accidents are often local expanded, so the grid emergency control can minimize the grid power outage losses from large area. At present the emergency control device is used mostly traditional "off-line strategy, real-time matching" plan, this scheme will inevitably be introduced error even mismatch, which will lead to be unadaptable to emergency control device. Accordingly, the emergency control scheme for improving "online strategy, real-time matching" is the development direction of emergency control [7].

Restore control in power system mainly recover power supply rapidly and safely. So, establishing black start plan is very necessary to shorten the grid recovery time. Currently, making black start scheme is mostly offline text-only form, and often consider only the most severe cases of black start scheme. However, the accident of power network is unpredictable, and offline black start scheme for guidance content for those dispatcher is not very practical, to help dispatchers online making restore decision-making, alleviate dispatcher pressure, reduce the possibility that make mistake, online black start scheme must be studied [8].

E. Optimization Maintenance Plan Arrangement

Chinese transmission line maintenance has long been arranged according to experience. As power grid scale is expanding increasingly and is affected by the weather and load level, power grid operation is more complicated. Empirical maintenance arrangement has been difficult to adapt to the power grid operation requirements. To formulate rational maintenance planning, dispatching center operation mode has become one of the important tasks. At present the maintenance plan of generating units have abundant achievements, but the maintenance plan of the line is relatively weak.

For transmission line, the probability of ice coating accident is larger because of long-term nudity in outdoor. It will cause power flow transferring and reduce transmission capability after line fault for ice coating. If transmission equipment is repairing in ice coating area, it will further aggravate probability of power failure and the system reliability will be dramatically reduced. Optimal maintenance start-up time should be studied for every line maintenance plan, simultaneously, coordination among annual maintenance plans, monthly maintenance plans and weekly maintenance plans should be also studied. Sometimes weekly maintenance plans still need adjust because of weather and operation mode and other factors. This grid ice coating accident give us some enlightenment, maintenance plan arrangement should consider the continuous weather forecast and uncertain factors, and it is of great important that risk theory and random fuzzy optimization are introduced to the maintenance plan optimization model.

F. The Display Platform of Power System's Operation State

At present, operation status display in power system is mostly confined to single problems, such as power system static security analysis, power flow analysis, and the applications is also separately, the lack of system implementation. In recent years, many major accidents occur frequently, one of the main reasons is the lack of mastery of the whole system to dispatcher. As shown in a single operating platform, the dispatcher can not be observed in non-electrical parameters of materials, especially natural disasters, power ice coating is slow in a particular formation of the natural environment. If the dispatcher observe the situation and take appropriate measures in initial stage of ice to the grid by displaying the ice platforms, the grid can be inhibited further intensified. Using multimedia technology to create animation, video and other means can provide a realistic operating environment for the dispatcher, which can help deal with ice coating accident.

G. Defect Forecast System inPower Ssystem

The electrical equipment will be worn, its operating life, reliability will be shortened in power accidents, weather, environmental and other factors. In recent years, Icing accidents has shown that early detection and elimination of defects in electrical equipment is to ensure the healthy operation of power systems. If the electrical equipment through the prediction of possible future defects is pre-judged and made measures to eliminate defects, accidents caused by ice load power losses will be reduced.

Currently, the prediction technology and the rapid development of computer technology for establishing power equipment defects forecast system provides a feasible. Defect prediction of electrical equipment depends on the accuracy of historical data and the accuracy and adequacy of a reasonable forecast. Management needs to have a well run power equipment management system, the history of defects in electrical equipment to collect, aggregate, and the formation of the corresponding database in order to accumulate a wealth of accurate data. The prediction is now more, there are: time series analysis, pattern recognition, expert systems, neural network method. Electrical equipment defect prediction system is a reasonable prediction by the power equipment history bug database analysis to identify defects in electrical equipment laws, predict the future may appear defective electrical equipment compatible with the maintenance plan for eliminating defects, thus the corresponding work consolidate the power grid structure and improve the resilience of the grid.

H. Ice Coating Accident Emergency Measures

November 1, 2007 China began implementing the "Emergency Response Act," intended to prevent emergencies and reduce the hazards emergencies. Grid ice coating caused the accident will not only damage, but also affect social stability. When the ice accident coming, power sector should work with local government leaders together constitute the emergency handling command organization in the early formation of ice storm, the power sector should promptly start power emergency incident handling plan, when the power facilities were serious damage, emergency response command shall organize relevant personnel to repair, rescue, ice to reduce disaster losses. When the power supply takes a long time to recover, the relevant departments of local governments need to maintain the power outage areas of law and order, safeguard the people's normal life and order.

I. Enhance Crisis Consciousness

Natural disasters (such as ice, floods, earthquakes, etc.) are irresistible, and power systems have inherent vulnerabilities, and small-scale incidents may cause a large blackout. It plays an important role to improve incident handling capability, enhance public awareness of the power system accident awareness and enhance the public's critical when the accident occurred to power workers.

IV. KEY PROBLEM OF CONSTRUCTING CLADDING ICE RECKONING DEFENSE SYSTEM

In recent years, a series of domestic and international large-scale power outage [10,11], resulting in huge economic losses, which caused the power workers and scholars attach great importance, and building security and

stability of defense systems has become a modern power system research hotspot [12].

Icing defense system established the purpose of disaster is through the ice on the grid to predict the severity and the real-time evaluation, the prompt start of appropriate measures for prevention and control of power in the shortest possible time to resume normal operation. Therefore, building a disaster prevention system icing key issue is to make the defense system in the state also have ice monitoring and prediction of dynamic, real-time network security level assessment of Ice, ice disaster emergency response capabilities.

A. Dynamic Monitoring and Prediction of ice Coating

Dynamic monitoring and prediction of icing in power system is the key to the establishment of non-electrical information-sharing platform. Icing can be used to monitor the dynamic multi-media technology to create animation, video and other means to achieve. Ice dynamic prediction is relatively complex, the formation of ice conditions: a sufficient temperature conditions may be frozen (typically less than 3 ℃), the same time with considerable humidity, the air relative humidity is greater than 90%, when the ice velocity usually 2 ~ 7m / s. Therefore, ice causing grid accident requires certain weather conditions a certain duration time. The whole process involves temperature, humidity, pressure, wind speed, wind direction and other meteorological factors, if timely meteorological information and data collected, and through time series method or methods of artificial intelligence, data processing, power can be predicted ice conditions.

B. The Real-Time Evaluation for Safety Grade in Power System

In different regions and in different time, power status and development trend of ice coating is different. Real-time evaluation for safety grade in Power System is based on dynamic monitoring and forecasting information to analyze the severity of the current grid ice coating so as to assess grid security level in the state of the current grid ice coating.

Grid ice coating is different during the same period of ice cover under the different regions of the grid. Ice in some regions may be relatively serious, and some areas may be relatively lighter icing, severe ice or in ice slightly regions, different components of different degrees of ice cover. Identifying the safe operation of the state power grid ice weak point is the level of safety critical real-time evaluation system. The real-time evaluation for safety grade in power system can be "extensive" and "refine" the principle of the severity of icing on the grid to divide high to low, combined with dynamic prediction of icing grid, identify the state power regional icing level of security of grid operation.

By "extensive" principle of ice dynamics were monitored, according to the severity of ice will be divided into a number of regional power grid. Then, click "refine" the principle of ice on each line or component within the region and further analysis of ice conditions, identify the safe operation of circuit or component level. "Extensive" the principle of power from the macro control the most serious regional ice, "refine" the principle of the micro grid to identify areas in need of attention icing lines or components.

C. Emergency Treatment System of Icing Disaster

Ice processing systems need to have emergency disaster prevention and control and recovery control functions, according to the severity of ice grid and grid-scale accident,, ice disaster emergency response system should be able to provide a reasonable de-icing measures, black-start plans , load recovery plans and recovery plans. The key features are: on the one hand ice level of security based on real-time evaluation of security classification system to provide the results to take appropriate control measures; the other hand, can combine the power grid running at the time and ice prediction system to dynamically generate dynamic contingency plans. Operation mode and the ice situation in the ever-changing, pre-accident plan preparation is often difficult to meet the requirements, the establishment of contingency plans for the dynamic production platform will be the emergency power system catastrophic ice core issue.

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