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The Application of the Real-time Temperature Monitoring System for Electric Transmission Lines

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Abstract

In the article, the influencing factors of the high-voltage transmission line running were analyzed, the important meanings of the real-time online monitoring of the line contact point aging for guaranteeing the safe and stable running of the lines were pointed out, the theoretical reference and the project selection of the high-voltage transmission line temperature monitoring were discussed, and the structure composing, working principle and running mode of the project proposed by the author were mainly introduced. The system designed in the article could prejudge the faults of the contact points and implement the state overhaul.

Keywords: High-voltage electric transmission line, Real-time temperature monitoring, Contact point aging

1. Backgrounds analysis

Overhead high-voltage transmission lines are the arteries of the electric power system, and their running states directly decide the safety and benefits of the electric power system. The contact point breaking is one of usual fault existing on the overhead electric transmission lines.

The mechanical connection parts of the connection electric power fittings such as double-line yoke plate (parallel cable clamp), strain clamp and connecting pipe in the high-voltage transmission lines often have many thermal defects because of oxidation corrosion, loose connection or bad fixing quality, and when the power transmission lines run, the temperature of these parts will rise, and the aging of these parts will be pricked up, and the contact resistances will further increase, and finally the lines will be broken suddenly. So the aging of the contact points of the lines should be monitoring online and warned at any moment to find out the thermal defects in the electric power fittings, implement the state overhaul, predict and prevent the occurrences of the power breaking accidents, and ensure the safe and stable running of the power transmission lines (He, 1987).

According to the experiences and experts' analysis, there are three reasons to reduce the overheating of the line contact points, i.e. the oxidation corrosion, loose connection and bad fixing quality. At present, there are two methods to judge the thermal defect. The first method is the warning temperature rise method which takes the temperature rise comparing with the temperature of the environment as the reference, and if the temperature rise exceeds the warning temperature rise in the standard warning temperature rise table, the thermal defect occurs. For the method, the environment temperature surrounding the lines is difficult to be measured, and the solar radiation and the influences of electric power fitting can not be considered. The another method is the relative temperature rise method which judges the thermal defect by analyzing the change relation between the relative temperature difference and the contact resistance, but in practice, the contact resistance is very hard to be measured (Zhang, 1991 & Cen, 1996).

Because of the deficiencies of above two methods, a new relative temperature difference method occurs, which can simultaneously measure the temperatures of the heating points, the neighboring lines and the environment, and compute the relative difference according to the following formula.

$$\delta = (T1-T2)/(T1-T0)*100\%$$

Where, T1 is the temperature of heating point, T2 is the temperature of the corresponding point and T0 is the temperature of the environment. The judgment references of the guide equipment defect include the common defect of "≥35%", the major defect of "≥80%" and the equal emergence defect of "≥95%".

This method can be used to eliminate the additive temperature rise induced by the solar radiation, and reduce the errors because of inexact parameters such as the detecting range, environment temperature, humidity and wind speed. This

method has good effect to judge the thermal defect in the practice.

The common fault exists in above all methods, i.e. the manual work needs to be used in the spot, but the electric transmission lines are distributed in the very wide regions, so these methods are meaningless for the lines checking with large region. The real-time and online function actualized in the system could solve this difficult fault.

2. Design of the temperature monitoring project

The locale sketch map measuring the contact point temperature of the high-voltage overhead lines is seen in Figure 1. The contact points of the lines are generally located near the pole tower, and the lines are hung on the pole tower by two clusters of insulator, and each phase of line have 2~10 contact points.

First, the temperature can be measured by personnel at the locale. The personnel can adopt two sorts of method. The first one is the remote viewing temperature coating method, i.e. several temperature coats with different colors are adsorbed on the line contact points in advance, and these temperature coats will melt under different temperatures, and the melting state of each coat can be observed by the telescope to judge the approximate temperature range of the contact point. Another method is to utilize the remote infrared video camera which can only exactly observe the temperature only in the cloudy weather, not in the rain day, and the errors and the costs are large. Above two methods all have their fixed deficiencies, i.e. they are largely influenced by the weather, and the measurement can not be implemented at any moment, and most lines are distributed in the wider regions, and the measurement will waste large numbers of manpower and materials.

Second, the method of real-time online monitoring can be adopted, in which there are three modes including infrared mode, optical fiber mode and wireless to be selected mode (Chen, 2003).

The infrared mode is to utilize the infrared temperature sensor installed on the remote end to measure the temperature of the point, and this mode can not be jammed by the electromagnetic field, and it needs not the contact with the personnel. But for the high-voltage electric transmission lines, because the measured object is too small and the measurement distance can not be too close because of the installation limitation, so the distance coefficient of the sensor D: S (the ratio between the distance and the diameter of the measured object) is required to be quite big, but there is the proper product to fulfill these requirements. A two-color thermometric indicator can measure the temperature of the remote small object, but it can only aim at the measurement object above 500℃. In addition, the infrared sensor can only be installed on the pole tower by the side of the lines, and the obstacles can not be located among the measured points, and the telescope needs to exactly aim at the object, which is difficult to be implemented in practice.

The optical fiber mode is to directly install the optical fiber sensor on the contact points of the lines, and transfer the data to the lower computer by the optical fiber. The optical fiber has the high insulated property, and it can not be jammed by the electromagnetic field, and it can be applied in the indoor high-voltage, but in the field, the rains and dews will reduce the insulated performances if they attach the surface of the optical fiber and induce the safety fault. One remedial method is to connect a cluster of insulators among the optical fibers, which will be too heavy, and fixed difficultly, and to monitor the contact points of the lines, tens of points should be measured by the side of each pole power. In above two methods, one point needs one sensor, and the costs of two methods are too high (Jia, 1998, P.61-66 & Zhang, 2004).

3. System design

Through comprehensively considering, a wireless temperature measurement method is designed, i.e. a micro control model is installed on each phase line, and the model is connected with many temperature collecting detector to collect the temperatures of many contact points and lines on the phase line, and the model transfers the collected temperature data to the equipment installed on the pole tower. This method will never influence the safety performance of the electric transmission lines, and through corresponding technical measure, the method can solve the problems that the wireless communication is jammed by the electromagnetic filed near the lines, and the power supply of the temperature measurement model and the temperature collection precision are easily be influenced by the high-voltage electric filed. In addition, the cost of this method is very low.

In the system, the networking mode that one monitoring center host machine matches with many outdoor slave machines (<100 computers) is adopted, and the wireless data communication is used by the GSM network. The system networking is seen in Figure 2.

Because the GSM network is used for the communication and the distances between the host machine and slave machines are not limited, so the system can be used in the regions that the GSM network could cover. This method can solve the problem of the networking distribution of lines, and the monitoring center can be moved at any moment without outdoor antennas with huge cubage and difficult installation, which makes the system more flexible.

The system can measure many parameters such as the contact point temperature of the high-voltage lines, the temperature of the lines, the temperature of the environment, the humidity, the wind direction and the wind speed, and

one outdoor slave machine installed on the pole tower can monitor 1~32 line contact points.

3.1 System composing

The system includes the outdoor slave machine, the center host machine and the system software.

The outdoor slave machines are installed on the pole tower of the field high-voltage transmission lines, and they are used to collect the data of various parameters which are transferred to the monitoring center after being processed, and they receive various orders from the center at the same time to implement the operations such as point measuring, modifying threshold setting, modifying time interval, and collating the clock. The powers of the outdoor machines are supplied by the solar battery with the intelligent charge management system which needs not maintenances for many years, and the life of the battery is 3~6 years. The micro-power-consumption UHF wireless receive chip is adopted between the outdoor slave machines and the temperature collection point to exchange the data and ensure the safety.

The monitoring center host machine is composed by the wireless receive equipment (GSM Modem) and the monitoring computer. The monitoring computer includes one industrial control computer server and many client computers which can read data on the server through the networking. The functions of the server and the client machines can be completed by one machine.

The system software is divided into three modules including the operation processing platform, the service control center and the database system, and these three modules can be respectively installed in different PCs or be installed in one PC. The software system could analyze and process the received contact point temperature and other data, and compute the temperature rise of the contact point according to the mathematical model, and offer the maximum temperature and the average temperature in certain period and the comparisons with the temperatures under other weather conditions, which could be referred for the monitoring personnel. The software includes the warning system which can alarm the monitoring personnel by the sound, light, or the short message. In addition, the software uses the advanced MapInfo geographic information system which can clearly display the actual geographic positions of various monitoring points, and amplify or shrink the map infinitely, and realize the intuitional human-machine interface.

3.2 Working mode

The working mode of the system is divided into the normal working, the warning and actively uploading, and the host machine transmitting orders.

When the system works normally, the outdoor slave machines check the parameters such as the temperatures and humidity degrees of various points, the wind direction and the wind speed periodically, compute, process and pack the data and transmit the data to the monitoring host machine according to certain time interval by the form of short message, and the system software of the center will process, store and displace the data. The time interval here can be set and modify at any moment by the management personnel through the system software.

The warning and actively uploading mode is that when the outdoor slave machine judges and checks that the temperature data exceed the threshold value set up in advance, it actively upload the data immediately.

The host machine transmitting orders mode means that the host machine can make various orders to the outdoor salve machines, and these orders include point measuring, collating clock, modifying the set of threshold, resuming the default setting and modifying the time interval that the salve machine transmits the data. And the point measuring requires that the slave machine measures the data and returns the measurement values at once, and the collating clock means the slave machine collating the clock to make all equipments in the system work at same clock system. The GSM module of the outdoor machine is always in the receiving state, and when it receives the orders of the host machine, it should respond immediately, complete the appointed operation and return corresponding information.

The contact point temperature measurement system is the difficulty in the design. The temperature collector and the wireless receiver must be installed on the high-voltage lines, but they can not use the power supply of the high-voltage lines, and they will be jammed by the stronger electromagnetic filed and the high-frequency harmonics, and once they are installed, they are difficult to be maintained, which bring more research tasks for this circuit. In the design, the special-made solar batter is adopted to supply the power for the module, and the special protection equipments for overcharge, over-discharge, and discharge times limitation are designed to protect the circuit. The power supply of the whole module is controlled by the clock chip, and the special control protocol is adopted to wirelessly receive the data to save the electric power and transfer the data reliably at any moment. The temperature collection doesn't use traditional analog signals, but the high-integrated digital temperature sensor which can not only transfer the digital signals but enhance the level of the signal to prevent being submerged by the strong noises of the high-voltage lines. All circuits in the system are screened specially, and the wireless communication uses UHF frequency and adopts multi-levels anti-jamming processing. In addition, to achieve the special application, all chips in the module design are the most advanced, high integrated, ultra low power consumption, anti-jamming and ultra small volume, which makes the whole collection system more artful and easily to be installed, and work stably without maintenances.

4. Conclusions

Through the usage of the system, the temperature change rule of the high-voltage overhead line contact point can be simply grasped, which can be used to prejudge the fault of the contact point and realize the state overhaul, and the relative reliability that the connection electric fittings are processed by the exploding press technology at present is proved. This system with friendly human-computer interface and powerful communication function can be applied in various ultra high-voltage transmission line protections, and it can not only offer intuitional judgment references for the management department and the first-hand data for the technical improvements in relative industries, but save large numbers of human powers and materials and produce large social and economic benefits.

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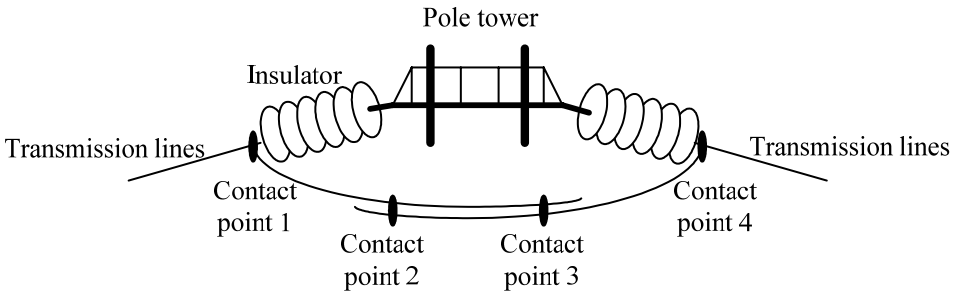

Figure 1. Sketch Map of High Voltage Transmission Line Contact Point Positions

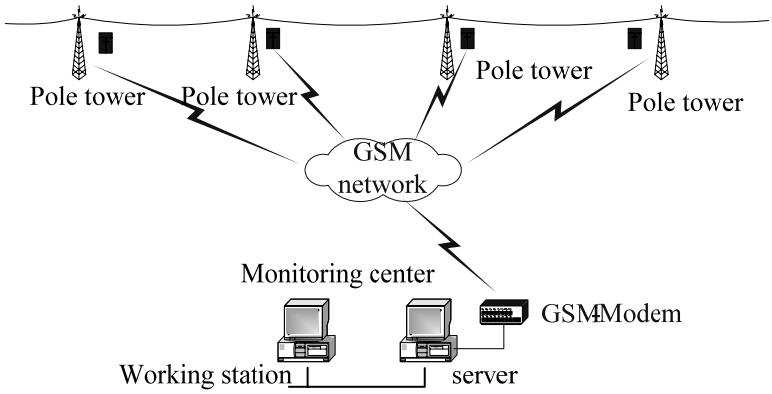

Figure 2. Sketch Map of System Networking