A New On-line Monitoring System of Transmission Line Icing and Snowing

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Abstract—**A New On-line Monitoring System of Transmission Line Icing and Snowing was designed and produced, the composition and the technical features of which were described, the modal of computing icing coating was built, and the hardware and software design of the on-line monitoring unit was introduced in details. The on-line monitoring unit placed on every transmission line tower timely measured the image of the iced conductors, the gravity of iced conductors, the deflection angel of insulators, the deviation angel of insulators for wind, gallop frequency of conductors, the wind velocity etc. and sent the above information to the municipal monitoring and controlling center by GPRS net. The conductor icing of transmission line belonging to Haidong power supplying company was measured. Until 1st February 2008, four icing accidents have been monitored by the system successfully. Through the analyses of the monitored data from 20 Jan 2008 to 27 Jan 2008, we can find that the metrology of the four icing accidents has some similarities: the ambient temperature is between -10℃ and 0℃, the ambient humidity is between 80% and 90%, the ambient wind speed is between 0 and 5 m/s and the wind directions are both south. The fact that conductor icing need certain metrology is firstly proved by running data.. Video apparatus is also designed, and the scene image can be captured in time. The image proceeding is also made and used to measure the icing status of conductors and insulators.**

I. INTRODUCTION

For the effect of macro-climate, micro-climate and micro-meteorology, the icing disasters happened frequently in China, which brought about tremendous economic losses[1]. For example, the weather of heavy icing in three-gorges areas of Badong – Wushan – Fenjie – Yunyang – Wangxian, which exert enormous effect on the operation of transmission lines during 12th to 20th January, 1998. The icing flashover, the galloping of conductors and the collapsing of towers on the 500kV transmission line happened in China in December,2004 and 2005. Because to the freezing rain that is seldom in history in Central China lead to the large scope of icing on transmission lines, where the thickness of icing on some transmission lines are beyond their mechanical loading, and the towers collapsed seriously, and the normal operation of power system was affected directly[2,3]. If the icing status of transmission line can be monitored and analyzed, then the operation reliability of transmission can be improved by alarming timely in terms of meteorology. But only the theory of icing, the mechanism of icing dodging as well as the design of tower's strength were studied all over the world. For example the system of monitoring, controlling and maintenances of transmission lines was developed in Japan, by which only some ambient external parameters, accident points and others parameters can be monitored and controlled[4]. In USA, the monitoring and controlling system of transmission lines was produced for monitoring OPGW[5], but this product often lacked practicality because it was restricted by the communicational methods and the technology of sensors. In terms of looking up new materials, there is no practical operating products of the on-line monitoring system of transmission lines icing. An on-line monitoring system of transmission line icing based on GSM SMS is developed successfully here , by which the on-line monitoring of the transmission lines icing is realized, by which the alarming signals at the earlier stage of heavy icing is sent immediately, and by which the loss of icing disasters can be reduced. The problem that the icing of transmission lines can't be monitored on real-time directly is firstly resolved. Importantly, the high-cost construction of icing coating observing stations can be replaced by this monitoring system. The accuracy of this system is very important, which is studied in details in this paper.

II. THE INTRODUCTION AND THE STRUCTURE OF THE SYSTEM

The whole system consists of the provincial monitoring center, the municipal monitoring center, the online monitoring unit and expert software etc., and the system topology is shown in Figure 1. The on-line remote-monitoring system of transmission line insulator contamination based on GSM SMS communication net is firstly produced. One on-line monitoring unit is placed on every transmission line tower, which can timely measure the above parameters of icing such as the environment temperature, the humidity, the wind velocity, the wind direction, the rainfall, the deviation angel of insulators for

wind, the deflection angel of insulators etc.. By GPRS/CDMA/3G communication net, both the system time and the sample interval of the monitoring unit can be modified remotely according to the command far away from the municipal monitoring center. The municipal monitoring center can estimate the icing status by analyzing the data from the measured towers, which can also remotely modify the running parameters of very online monitoring unite by GPRS/CDMA/3G communication net. The municipal monitoring centers are connected to the corresponding provincial center by LAN, which can directly determine the conductors icing and galloping status of all transmission lines in the province by receiving the force, the angel, the galloping frequency, the temperature, the humidity, the wind speed, and the rain fall of some towers from every municipal center. The modified theoretical modal, experimental results and running results are used to determine the status of icing and galloping of conductors by the expert software and the alarm model. The expert software can intelligently draw the force, the frequency, the wind speed and the stress figure corresponding to time, and give out an alarm message of clearing ice.

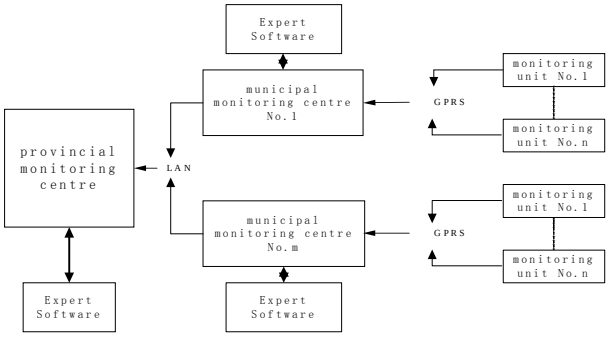


Fig.1 System topology

III. THE DESIGN OF ON-LINE MONITORING UNIT

A. The Selection Of The Monitoring Parameters

Mostly, the climate in the icing areas is extremely complex, in the light of the observing materials from the icing observing station, the relation between the icing status of conductor and meteorology is analyzed. We can know that the icing status, the ambient temperature, the humidity and the wind speed are in relation forcefully, so the ambient temperature, the humidity, the wind speed, the air pressure, the wind direction even the rainfall and some other parameters should be monitored by the monitoring system. Considered the operating voltage of transmission lines is high comparatively (over 220kV) and the reliability of sensors which are equipped on the towers, the variety of icing gravity is properly measured to compute the thickness of icing. The accident of Central China grid in 2005 shows that in most situations, the towers seldom collapsed directly, but they are twisted and destroyed for the horizontal force caused by unstable icing between the two sides of the towers[3]. So the insulator string's deviation angel of insulators for wind, and deflection angel of insulators should be monitored. In sum, the deviation angel of insulators for wind, the deflection angel of insulators, the variety of icing gravity, the temperature, the humidity, the wind speed, the wind direction, the rainfall, the air pressure and other parameters should be monitored.

In additional, a video apparatus should be installed, by which the scene image can be captured remotely and by which the comparative analysis can be made also.

B. The Function Of Online Monitoring Unit

The scene image or video, the deviation angel of insulators for wind, the deflection angel of insulators, the variety of icing gravity, the ambient temperature, the humidity, the wind speed, the wind direction, the rainfall, and other parameters should be sampled and sent to the monitoring centre. After various type of signals are magnified and isolated, the magnified and filtered signals will be delivered to 16 bit A/D convector, and the variety of conductor gravity, angles, wind speed, environment temperature and humidity and other environmental parameters will be recomputed by MCU. On one hand the preliminarily processed data will be transmitted to the municipal monitoring center by GPRS/CDMA/3G, On the other hand, the effective data are storied in large flash memory where data is not easy to lost. In the light of controlling signals sent by online monitoring center, the historical data can be collected and storied on real time, the monitoring unit's sampling time can be revised, and its time can be calibrated, and other running parameters can also be modified remotely.

C. The Hardware Design Of Online Monitoring Unit

Because the monitoring unit works outsides the door, it is required to be low power dissipation and operate with no maintenance. The variety of icing gravity, the deviation angel of insulators for wind, the deflection angel of insulators, the environmental wind speed and other messages are mainly collected, storied and transmitted by MCU. For storing data effectively, a flash-memory is chosen and even the power of monitoring unit is off, the data can still be storied over 10 years effectively. Its block principle is shown as Fig.2. The MCU can timely control the work of camera (the automatic alternation of camera between daytime and night) with the requirement of the remote monitoring center, the video signal sampled by camera can be compressed into standard files of MPEG4 by the DSP compressing module. Every monitoring unit installed on tower can monitor the gravity of two separate strings insulators and conductors. The monitoring unit is consisted of solar cell panel, charging circuit, high-property battery, flash-memory, low-consumer single chip processor, 16 bit A/D convector, the temperature and humidity sensors, GSM communication module etc..

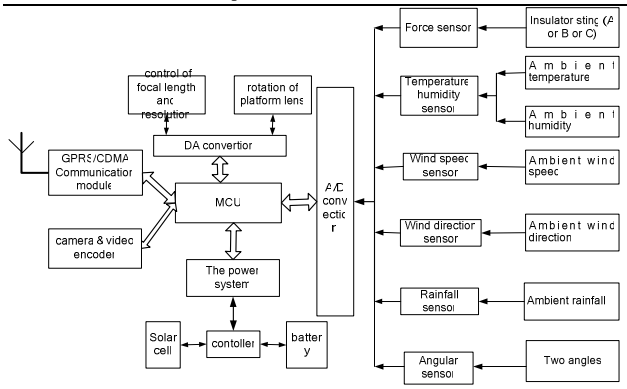


Fig.2 The block principle of online monitoring unit

C. The Combination Of Cameras

Considered different users want to monitor different objects, for example some people want to monitor the conductor icing, some the growing of trees nearby the transmission lines, some the gallop of transmission lines, some the building around transmission lines, some the stolen behavior of tower materials and etc.. At present the combinations of camera's design is shown as follows:

(1) single fixed one-piece camera(fixed for one object, focusing can be realized);

(2) one-piece camera + infrared camera (fixed for two objects, one is realized as focusing, and the other is used as camera especially for at night);

single all-directions camera (at most 128 presetting locations can be selected remotely in the centre). This setting is very important for several objects with one camera, such as this system is used to monitoring the scene of Huogang 5305 crossing of 500kV transmission lines belonging to Wuhu power supply company.

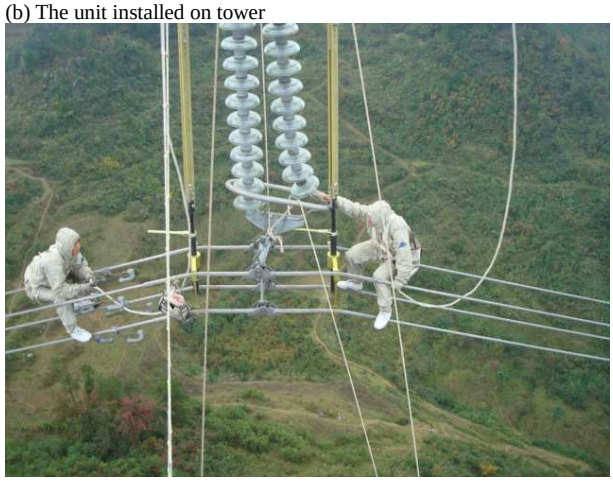
D. The Software Design Of Online Monitoring Unit

According to the system function required, the software of the online monitoring unit will finish the initiation of I/O and flag register, make A/D conversion, transfer the contamination data into the city monitoring and controlling center by GPRS/CDMA/3G, and check the symbol of stopping accepting data.

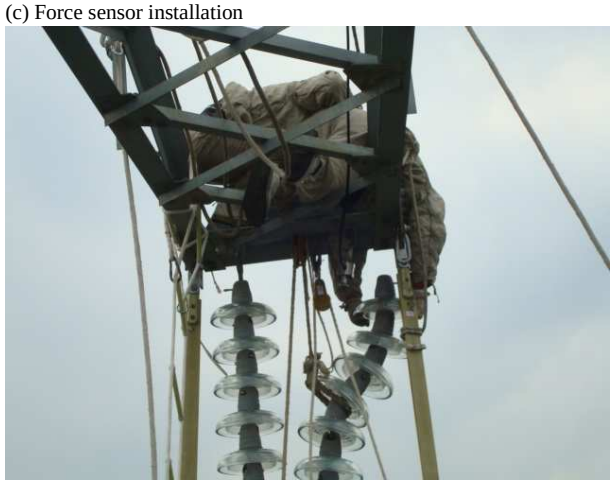
E. The Installation Construction Of Online Monitoring Unit (as shown in Fig.3)

(a) Installation scene

(b) The unit installed on tower



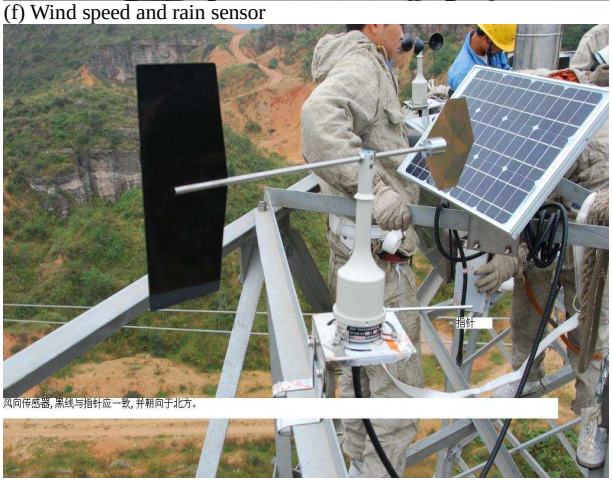
(c) Force sensor installation



(d)Force sensor installation

(e) the installed force sensor

(f) Wind speed and rain sensor



(g) wind direction sensor and solar bar

(h) Video

Fig.3 Installation of online monitoring unit

F. Expert Software

Some important parameters of the towers can be monitored by the expert software installed in the monitoring center. Based on the relation of the thickness of icing, the deviation angel of insulators for wind, the deflection angel of insulators, the conductor tension, the conductor arc length, the ambient temperature, the humidity, the wind speed, the wind direction, the rainfall and other environmental parameters, the real-time data from every monitoring unit can be analyzed and judged, the status of conductor icing and deicing can be analyzed and judged, then the alarm message can be sent timely before the thickness of icing approaches to the designed thickness of icing. Moreover, the alarm messages can also be sent to the manger or the correspondent leaders by GPRS The information about the variety of iced conductor, the thickness of icing, the conductor tension, the deviation angel of insulators for wind, the deflection angel of insulators, the ambient temperature, the humidity and other information are managed by the expert software, which can be selected, analyzed, and printed separately and adequately. The provincial monitoring center has the right to look at the icing status of every tower of every transmission line .The main interface of expert software is shown in Fig.4.

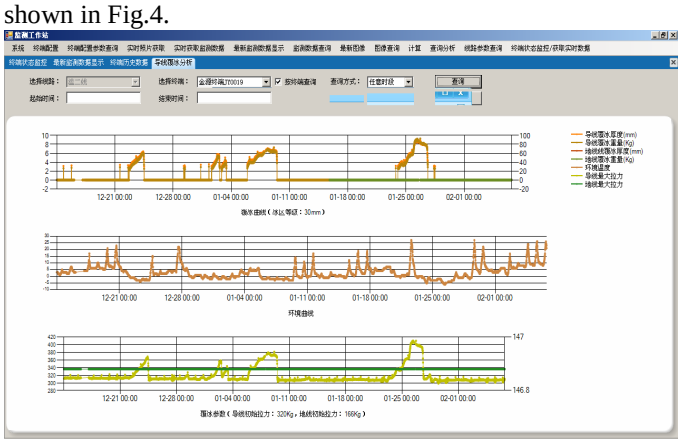
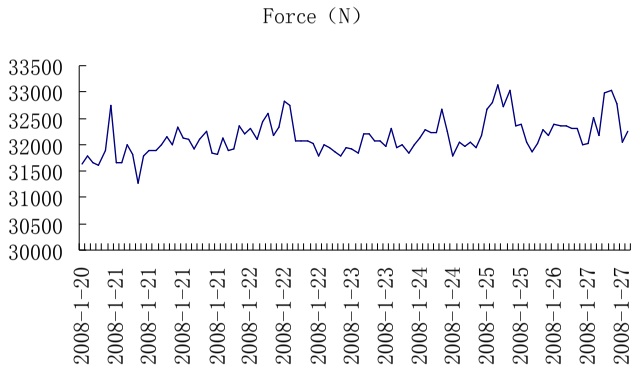


Fig.4 Expert software

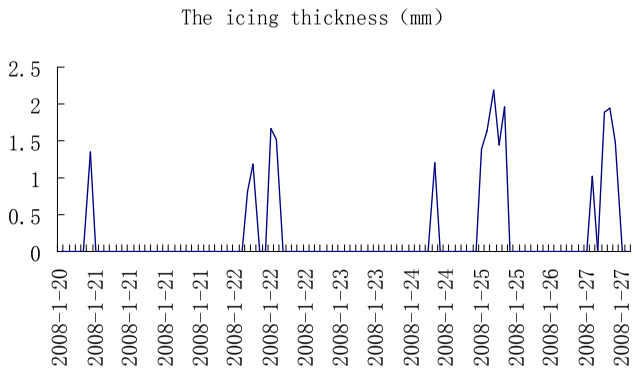
V. ANALYSIS OF RUNNING RESULTS

A. Icing Status Analysis Based on Force

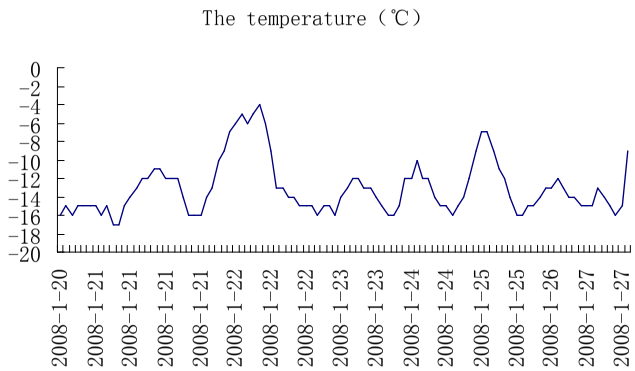
The on-line monitoring system of transmission line icing was finished successfully in October,2005 and was installed and operated in heavy icing areas of Haidong power supplying corporation in Qinhai province in April.2007 and the equipment works well at present. The effective dynamic database of icing and micro-meteorology has been built, so the icing information is shared in different departments and basic data is supplied for the design, the operation as well as the maintenance of transmission lines. Until 1st February 2008, four icing accidents(shown as Fig.6a and Fig.5b) have been monitored by the system successfully. Through the analyses of the monitored data from 20 Jan 2008 to 27 Jan 2008, we can find that the metrology of the four icing accidents has some similarities: the ambient temperature is between -10℃ and 0℃ (shown as Fig.5c), the ambient humidity is between 80% and 90% (shown as Fig.5d), the ambient wind speed is between 0 and 5 m/s (shown as Fig.5e) and the wind directions are both south. The fact that conductor icing need certain metrology is firstly proved by running data.



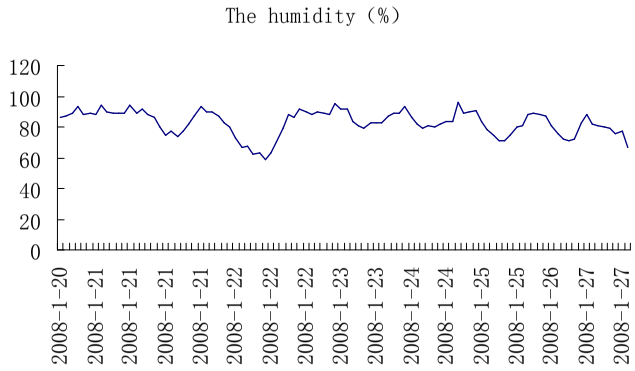
(a) the variety of vertical loading



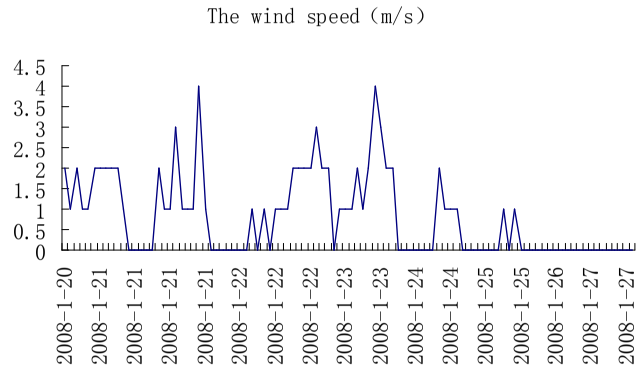
(b) the variety of icing thickness



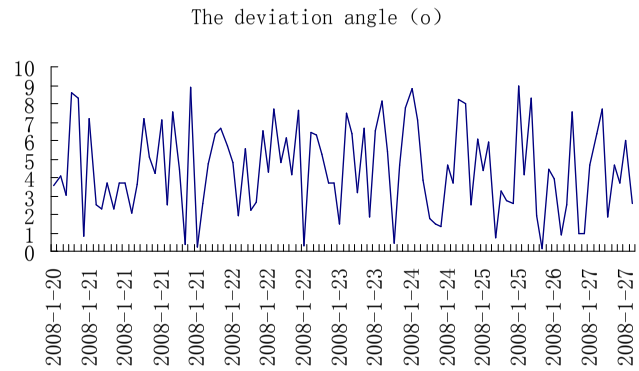
(c) the variety of ambient temperature



(d) the variety of ambient humidity



(e) the variety of ambient wind speed



(f) the variety of deviation angle

Fig.6 the data monitored on the icing spot

B. Icing Status Analysis Based on image

The icing disaster can be avoided by the video. For example, the process of the icing of towers and conductors is recorded by videos captured and by some meteorology parameters monitored by the system, which is installed on Xichang 329 line, Wuhu Power Company of Jiangsu Province, as shown in Fig.7.

（a）2008-2-5 10:06, T=3℃, H=60%

（b）2008-2-6 10:06, T=0℃, H91%

（c） 2008-2-7 10:05, T=-3℃, H=99%

（d） 2008-2-8 10:06, T=5℃, H=86%

Fig.7 the process of the icing Xichang 329 line, Wuhu Power Company of Jiangsu Province, recorded by video remote-monitoring system of transmission lines

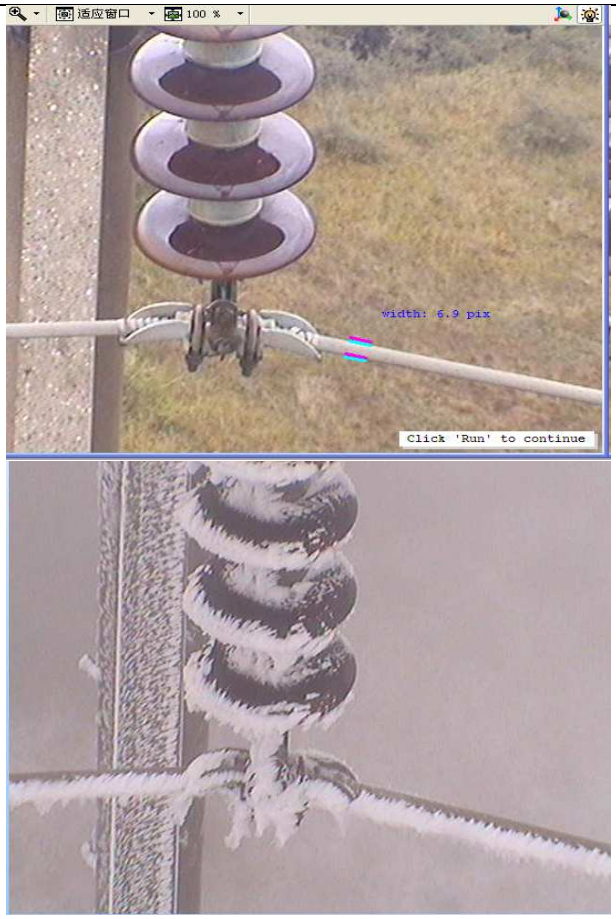


Fig.8 the normal and icing image of conductor and insulator

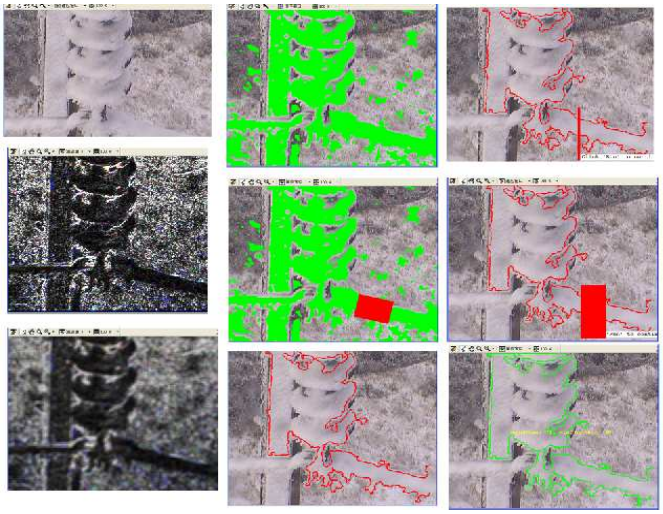


Fig.9 the image procession

C. Image processing

By image, we can see the icing status by our eyes. But we can't calculate the icing thickness. With the development of image processing, it's possible to calculated the icing status by the image varity. The author has done some work about it. The original image is shown in Fig.8, and the image processing is shown in Fig.9, by which the icing thickness can be analyzed automatically..

VI. CONCLUSIONS

The micro meteorology (such as the humidity, the wind speed, the wind direction, rain, snow, and air pressure) and the icing status of transmission lines (such as the deviation angel of insulators for wind, the deflection angel of insulators, the gravity variety of icing, the galloping frequency of conductor and so on) can be monitored by the on-line monitoring system of transmission line conductor icing based on GPRS at the same time. With the available forceful communication net of Mobile and Union, the measured data as so as the video can be transmitted in time. Based on theoretical models built, the status of icing can be

known and forecasted, and the messages of icing elimination can be sent timely, which can help to take precautions against icing disasters effectively and immediately. The dynamic database of icing and micro-meteorology can be built on the real time, which can be shared by different departments and supplied for the design, operation and maintenance of transmission lines, which is important to the modification and accidental reconstruction in heavy icing areas, based on which the further theoretical and regular study of conductor icing can be made.Moreover, the 3G interface is reserved in this system, then video information can be realized on the 3G network..

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