ONLINE TEMPERATURE MONITORING INSTRUMENT FOR CONTACT OF CIRCUIT BREAK TRUCK IN AIS SWITCHGEAR

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ABSTRACT

The badly contact of the circuit breaker (CB) truck's contact in AIS switchgear may cause the over-heating of the contact and induce the burning out or even flash over accident. To prevent such faults, a new instrument for monitoring under operation based on the information coding modem and wireless communication technologies had developed. This online monitoring instrument can detect the temperature of the contacts and the ambient temperature in the AIS switchgear. The installation of the instruments is insulation guaranteed and it can work without any additional power sources. By the benefit of using wireless communication to transmit the data collected, it can gathering data from different switchgear and different substations to form a monitoring network for the AIS switchgear truck contacts temperature. In this paper, the structure of the instrument, its mounting method, the collection of the temperature data and its operation experiences is introduced.

INTRODUCTION

Up to now, the accidents of burning out or even flash in AIS switchgear resulted from overheating of bad contact of the circuit breaker (CB) truck's moving and static contact still have not been found effective methods to monitor and control. It has become a big obstacle for the safe operation of AIS switchgear. The normal operation of electric power system is disturbed with the consequences of great economic losses. Therefore, it is necessary to develop an economical and practical on-line monitoring equipment of the temperature rise of contact in the power industry. The aim is to provide the on-line temperature monitoring instrument (OLTMI) for the key parts of the switch equipment under operation, such as the truck's moving and static contact of CB etc in the premise of ensuring the insulation performance of the existed equipment. The relevant analyzing result and alarm can also be given simultaneously in order to improve the safe and reliable operation of AIS switchgear.

COMPARISON OF THE EXISTED MEASUREMENT METHOD

Temperature indicating recorder labels

The temperature indicating recorder labels are affixed to the contact place of conductor when power cut. If the melting phenomena are found in the recorder label when the equipment is in operation, it can probably judge the heating degree of the contact. The accuracy and reliability of this method is poor and can not be used in quantitative measurement.

Infrared rays diagnostic technique

Infrared rays diagnostic technique is to measure the temperature of the equipment surface and the distribution of temperature field through the absorbed radiated energy of infrared rays and then to judge the heating degree of equipment. The accuracy and reliability of this method depends on the factors of distance, atmospheric background and the radiation rate of objects etc. It can not be applied to measure the temperature rise of CB truck's contact located in the AIS switchgear.

Optical fibre sensor technique composed by Fabry-bert slot

The Fabry-bert slot is composed of thin slices of silicon. The rectangular slots are fluted in the upper and bottom of the middle section of thin silicon slices. A single layer of glass is affixed to the upper side of thin silicon slices. The heat expand coefficient of the glass and the silicon slice is different. When the temperature changed, the heat expand coefficient resulting from the different material produces the interior stress in the place. The interior stress changes the depth of the slot. The multi-color lights are sent to the Fabry-perot slot by the optical fiber. The modulated lights are also delivered by the optical fiber. The main wave length of the modulated multi-colored light varies with the change of the depth of Fabry-perot slot. Since the variation of temperature is continuous, the variation of the depth of the slot is also continuous. Consequently, the main wave length is the continuous function of the temperature. The components of the optical fiber sensor system composed by Fabry-bert slot are small and skillful with high corrosion-resistance property and measurement sensitiveness. It is also immune to the electromagnet disturbance. However, the whole equipment is expensive and the economic performance is poor.

DEVELOPMENT OF OLTMI FOR CONTACT OF HIGH-VOLTAGE CB TRUCK IN AIS SWITCHGEAR

Principle of the temperature-measurement technique and structure of the instrument

The developed instrument includes high-voltage part module and low-voltage part module. The high-voltage part module is consisted of temperature sensor, temperature sampling unit, comparator unit, signal transformation and emission unit and power supply (small CT winding), which is illustrated in figure 1. The low-voltage part is consisted of decoding circuit, rectify and filter unit, alarm circuit and power supply. It is illustrated in figure 2. The principle block diagram of the OLTMI for contact of the high-voltage CB truck in AIS switchgear is showed in figure 3.

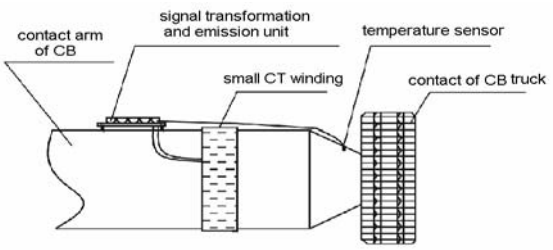

Figure 1: Structure of high-voltage part module

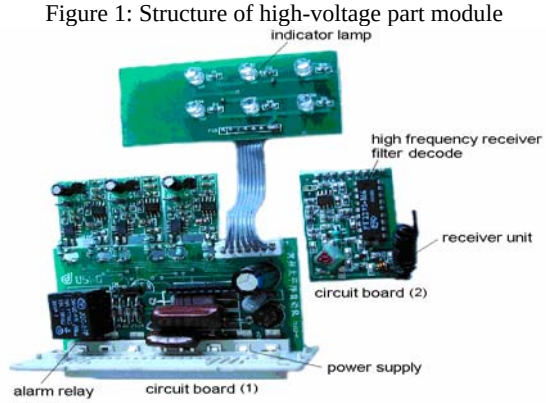

Figure 2: Structure of low voltage part module

The temperature sensor in the high-voltage part module is the PTC resistance with stable performance which is embedded in the contact of CB truck. The value of the resistance varies with the temperature. It joins with the signal transformation module through the high temperature lead and then enters the comparison circuit. When the current in high-voltage part exceeds the 50A, the output of the small CT winding provides the power supply for the signal processing, signal emission and instruction receiving component. The value of resistance varied with the temperature is first transformed into the voltage signal, and then is compared with the preset voltage signal. Suppose the preset voltage signal means 100 centigrade. When the temperature of the place where the PTC resistance is installed exceeds 100 centigrade, the input voltage of comparator will lower than the reversal potential which is preset as 100 centigrade. The output of the comparator changes from low to high, which makes the input of the emitter turning into high potential. The emitting signal of wireless code module is trigged. The temperature analog signal is transformed into the impulse digital signal by the microprocessor chip AT89C2051. Different values of temperature correspond with the different impulse coding. The impulse digital signal together with the coding signal of sensor address are modulated into the carrier frequency of 315MHz and the encoding signals which correspond with the temperature variation of the place where the PTC resistance are installed are emitted.

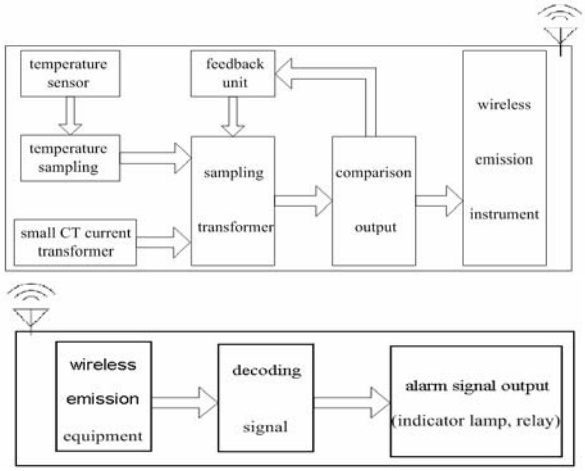

Figure 3: Principle block diagram of OLTMI for the contact of high-voltage CB

The receiver unit in the low voltage module part is consisted of high frequency receiver and amplifier, rectify and filter unit, encoding circuit and alarm circuit. The wireless signal which carries the temperature variation message and address message encoding is first amplified by the high frequency amplifier, and then is imported into the rectifying and filtering circuit to filter the high frequency carrier wave. The low frequency is input to the decoding circuit to decode, and then the address of overheating fault contact is obtained. Later, the alarm signal is given off. The temperature data, address of fault contact and the alarm message can also be sent to remote places by the RS485 serial interface to realize the connection of different systems.

key technique and safe performance

Power supply technique of current transformer (small CT winding)

The power supply of current transformer is one of the key techniques in the developed over-heating alarm equipment. In the course of design of this kind of power supply of the equipment, the heat-insulating performance, insulation and good stable performance should be taken into account. If the chemical battery is used, the lithium battery or fuel battery can not meet the requirement of life extension and continuously provide the stable and reliable power supply. The replacement of the battery under the uninterruptible power supply of primary equipment can also not be realized. If the photovoltaic battery is employed, the stable energy sources can not be supplied, since it is impossible to install the light source in the insulated sleeve of CB.

The settled scheme is to install the current transformer in the bus to extract the current to provide the power for the succedent temperature-measurement sensor circuit. The variation of current in the circuit bus varied from several tens ampere to several kilometers ampere and the variation range is over ten times. In order to ensure the relatively stable power supply provided by the current transformer, it is necessary to utilize the magnetic saturation of iron core. That is to say to select the intersection area of iron core and the permeability of ferromagnetic material properly to ensure the normal excitation of the current transformer when the current flow through the bus. Once the large current flow through the bus, the magnetism in the iron core is saturated and the inducted electromotive force varies slowly. If the constant-voltage tube is added, the relatively stable power supply can be provided for the temperature sensor circuit.

Message encoding and transmission technique

The address message of CB truck's contact and the temperature message of the contact are in high potential. The fault alarm unit is in low potential. In addition, the system is located in the severe electromagnetic disturbing environments. Therefore, it is important to solve the problem of accurate transmission of the message under the different potential and the severe electromagnetic disturbing environments. The wireless encoding technique is adopted in the equipment. Eight address ports (A1~A8) and the data ports (D1~D4) are set in the encoding module. The eight address ports can be combined randomly to obtain the different address. The data port can form 15 bit number. Then there are several hundred million different data to output through the different combination of address code and data code. The wireless encode emission code emits the encoding message which carries the temperature variation message and address message. The receiver module receives the encoding message which carries the temperature variation message and address message. The message between them is transferred through encoding and is corresponded one by one. Through this way, that is to say, the message is transferred by message encoding, modulation, demodulation and then transmission, the signal between high-voltage and low-voltage is isolated. Consequently, the immunity to electromagnetic interference is also improved.

Safe performance

The OLTMI for contact of the high-voltage CB truck in AIS switchgear is composed of the relevant electronic circuit, sensor, wireless emission and receiving equipment. It is installed in the contact of high-voltage CB truck. It is required that the assembled over-heating monitoring system of the contact is able to realize the on-line monitoring of the temperature arise of the overall six CB truck's contact. Moreover, the existing technique and insulation characteristic of the CB is not influenced. In order to meet this demand, the following measures are adopted in the course of the design and implementation of this scheme to ensure the existing technique and insulation characteristic of the CB and the monitoring circuit to work long and reliable.

(1) Emission circuit and sensor are installed to closely affix to the contact arm of each phase of the CB with the aim to make the circuit locate in the insulation sleeve of contact arm completely. Simultaneously, the measures of heat-shielding and anti-vibration are applied during the installation to ensure the existing relative insulation distance is not influenced. So the existing insulation capacity is ensured.

(2) When designed, selected and installed the sensor, connection line and various parts of electronic components, resistances to high temperature and over-current and over-voltage shock of various parts are taken into account. The aim is to ensure those section of the equipment to work long and reliable under the badly background where the CB truck is operated.

The working current of each phase is taken by small CT to provide the power supply for various parts, which ensures that no correlations of the electrical connection are existed between each phase. Once the over-heating phenomenon in the contact of each phase occurs, the wireless signal is sent by the monitoring equipment immediately. The receiver equipment distinguishes the phase which the over-heating occurs via accepting the decoding circuit and lightens the corresponding indication lamp to issue the alarm. The alarm signal of over-heating of contact is also given off. The signal sampling, transmission and alarm are sent and received through wireless to realize the potential isolation transmission between the high-voltage part and the low-voltage part.

Trial operation case

The OLTMI for contact of the high-voltage CB truck in AIS switchgear are come into trial operation in the 35kV GaoJia substation of JiaDing power supply sub-corporation of SMEPC. The six temperatures of upper and under contact of A, B and C phase, temperature and humidity of environment are loop sampled by the equipment. The range of measurement is from zero centigrade to 150 centigrade. The range of accuracy is $\pm$ 1.5% FS. Table 1 shows a group of recorded data of CB under the normal operation.

In addition, the action accuracy of equipment to monitor the limit value of 100 centigrade of over-heating alarm is detected after the OLTMI is installed completely. The sensor is heated via the electric hot blower. Meanwhile, the surface temperature of the sensor is measured through the infrared heat radiation imagery. The temperature of the sensor is increased gradually. When the infrared heat radiation imagery indicates that the surface temperature of the sensor has arrived at 99.2 centigrade, the red lamp in the low-voltage part module of the equipment corresponding to the contact is lightened, which means that the contact exceeds the temperature limit value. At the same time, the alarm relay acts and the alarm signal of over-heating is emitted.

Table 1: A group of recorded data of AIS switchgear under normal operation[1]

Visiting time	Current (A)	Temperature (℃)		Temperature (℃)		Temperature (℃)		Temperature inside the AIS switchgear (℃)	Temperature inside the AIS switchgear (%)
		AUC	ALC	BUC	BLC	CUC	CLC		
Sep.30, 2005	105	25	25	24	24	24	24.5	25.5	56
Oct.12,2005	100	24.5	24	24	24.5	24	24	25	57
Oct.20,2005	100	24	25	25	24	25	24	25.5	55
Oct.31,2005	101	24	25	25	24	25	24	25.5	55
Nov.9,2005	100	23	24	23.5	24	23.5	24	25	54

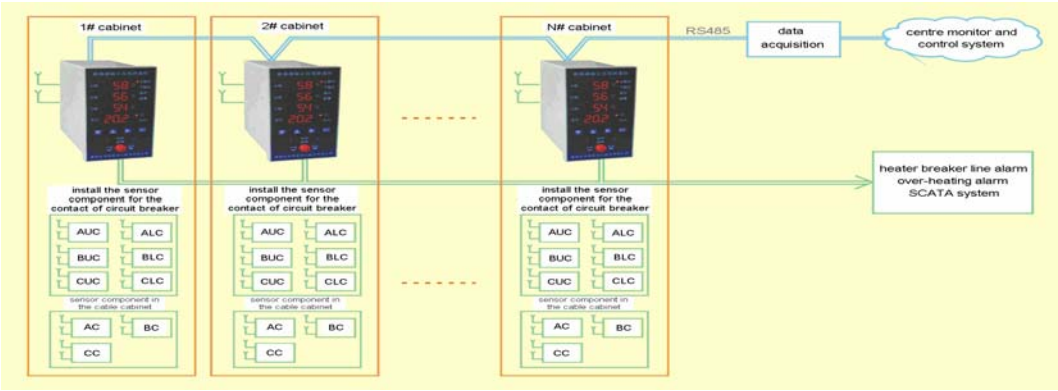

Figure 4: Schematic representation of the remote data sampling, monitor and control system of real time contact temperature rise of CB

It is proved by the trial operation that the OLTMI for contact of the high-voltage CB truck in AIS switchgear is operated reliable and stable. It can realize the real-time on-line monitor the temperature variation of each contact and the variation of temperature and humidity of the high-voltage cabinet. The over-heat condition of the contact can be correctly reflected and emit the alarm signal.

REMOTE DATA SAMPLING AND MONITORING SYSTEM OF THE REAL-TIME CONTACT TEMPERATURE RISE OF CB TRUCK

The following shows an example of the equipment applied in one substation. A set of the OLTMI for the contact of high-voltage CB truck are assembled in each AIS switchgear to achieve the sampling, display and alarm of the temperature of the upper and low contact of A, B and C phase of CB truck, temperature and humidity of environment. The OLTMI for the contact of the high-voltage CB truck from the number 1 switchgear to the number N switchgear are linked in the form of bus via the RS-485 serial interface. The data of various parts are transferred separately to the sample terminal. All the data of the place where the temperatures are detected of each switchgear, temperature and humidity of environment are directly transferred to the monitor and control center via ether net through the build-in net card located in the sample terminal. The remote data sampling, monitor and control system of the real-time contact temperature rise of CB truck in the substation can thus be formed and is illustrated in figure 4 particularly[1]. Various kinds of application function monitor and control software such as the query of the temperature history curve etc can be developed according to this system. As a result, it can truly realize the condition maintenance of the AIS switchgear contact.

CONCLUSION

The temperature transmit and signal emission system of the OLTMI for contact of the high-voltage CB truck in AIS switchgear are installed on the side of truck moving contact of breaker, which is convenient to install, maintenance and repair. The power supply of the transmit unit is taken from the current of the bus. So it is unnecessary to install the battery additionally and have high practicability. The existing insulation performance of the high-voltage switchgear is not influenced. The systems can real-time monitor the temperature variation of contact and have the function of displaying the value of contact temperature and alarming when the temperature exceeds the preset limit value. Moreover, the data of contact temperature can be transferred to the monitor and control centre via ether net. The remote data sampling, monitor and control system of the real time contact temperature rise of CB truck in the substation can thus be formed. It is beneficial for the improvement of the safe operation of switchgear and the power supply reliability of the power grid.

1 The symbol of AUC, BUC and CUC refer to upper contact of phase A, B and C separately. ALC, BLC and CLC refer to lower contact of phase A, B and C separately. AC, BC and CC refer to connection of phase A, B and C separately.