S1-17 CP1377

Infrared Technology in the Fault Diagnosis of Substation Equipment

Yang Cao, Xiaoming Gu, Qi Jin
Shanghai Electric Power Company Shanghai Branch Southern Power, 200030

Abstract: With the development of infrared technology and the further application in electric power system, it plays a more and more important role in electrical equipment fault diagnosis. Improving the accuracy of infrared diagnosis technology and its application effect is of important practicality value to the research of infrared diagnosis application technology. From the point of electric power system daily patrol, the paper expatiates how to diagnose the most popular radiation fault and trouble using the infrared imaging equipment, the operation process of obtaining infrared images of electrical equipment and the analysis of infrared images. In addition, the paper presents a series of management methods associating with infrared diagnosis daily work.

Keywords: Infrared diagnosis; Substation equipment; Heat failure

0 Introduction

Early diagnosis charged grid to run the equipment failure is very important problems in the past often taken overhaul on a regular basis. Since the advent of infrared imaging system, due to its fault detection can be charged, and to take non-contact means, so as to greatly facilitate the users, so that the electrical equipment failures in the early diagnosis and preventive maintenance has become easy and convenient. Infrared imaging system for diagnosis of thermal power equipment with a hidden fault-efficient, accurate, visual images, safe and reliable, non-contact temperature measurement, free from electromagnetic interference, the detection range, detection is fast and there is no need to make test equipment Or dissolution of the outage, and other advantages in power system fault diagnosis has been a wide range of applications, has achieved remarkable results for the repair of equipment provided to enable more targeted to deal with deficiencies, in order to carry out maintenance of equipment has created conditions for effective To prevent a number of accidents has greatly enhanced the reliability of the equipment running. It can be said is that infrared imaging system detected abnormal electrical equipment hidden ideal temperature apparatus, is predictable in the field of maintenance as a means to promote universal. Infrared thermal imaging detection technology in the power industry in the application for improving the reliability of the electrical equipment and operating cost, reduce the maintenance costs are very important.

1 Infrared technology in power system fault diagnosis

Infrared thermal imaging detection technology in the industrial countries to promote the use of universal to be from the original electrical equipment and power lines began to expand into power plants and other parties concerned. Infrared technology has become a diagnosis of electrical equipment monitoring, survey, found hidden in a timely manner, timely repair, and put an end to the vicious sudden incidents of-the-art equipment means. As we all know, power equipment, most of the accidents was not unexpected, often sooner or later there is a process of change. Electrical components gradually loosen, break down, such as corrosion, resulting in increased contact resistance, resulting in electrical components temperature, thermal anomalies occur. Thermal imager using direct observation and measurement can be found in these abnormal phenomena, have the potential failure of the location and extent of the problem.

Live on the infrared detection equipment to carry out diagnostic work in the framework of the Shanghai Municipal Electric Power Company has carried out a number of years, from the use of infrared point temperature instrument, infrared TV, the current un-cooled infrared focal plane, from which Accumulated rich experience in running, and found the solution to many problems such as bad, bad insulation, insulation aging, and so on, as well as the design, construction, operation, there are other defects in Shanghai for the safe operation of power grids to provide a reliable guarantee.

1.1 Infrared technology in power transformer fault diagnosis

Experience has shown that running, transformers accidents are often sudden, unexpected accidents in addition to those caused by lightning damage to the transformer, and strong external short-circuit electrical power transformer caused damage to the insulation and the normal operation even if the insulation breakdown accident, not Transformers are small and unforeseen long-term potential of the fault developed. As a result, accurate diagnosis and timely manner to deal with potential transformer failure of transformers to ensure reliable operation of great significance. Following is a list of some of the common use of infrared imaging system for power transformer fault diagnosis example:

- Eddy current transformer box as a result of wear and tear caused by the heat: transformer in the magnetic flux leakage of the eddy current loss will have, it can cause transformer box or in part, screw connections fever, which is based on characteristics such as heat leakage through the magnetic center for the region, Structured irregular circle. As a result of this eddy current loss caused by the heat box temperature generally should not exceed 95 ℃, if over-temperature, to be conducted on the transformer maintenance outage, the defects can be used to install short-circuit loop approach to the elimination of magnetic flux leakage phenomenon.
- Transformer as a result of internal heating caused by abnormal: when internal transformer as a result of bad or other causes fever, is likely to cause local transformer box temperature. This situation caused by the heat box vortex as a result of transformer and the loss caused by the heat is the biggest difference between the thermal spectrum does not have the shape of circulation, and defects such as over-temperature heat source at the same time with multi-gasification of transformer oil can be Chromatography combined with oil to determine the specific.
- Transformer oil pipeline plug: When the transformer oil pipeline plug, not the normal transformer cooling, thermal characteristics as part of the pipeline is blocked, or because the radiator did not participate in the oil cycle and a low temperature area, other parts of the relatively high temperature, Two distinctly different temperatures, the heat of the spectrum is clear response.
- Transformer oil pillow or high-voltage casing out of oil: transformer in the operation of the frequent casing high-pressure oil or pillow out of oil, which passed after the temperature in the thermal infrared spectrum, we can clearly see that, because of oil or pillow sets Oil and gas pipe by heat radiation, thermal spectrum, it is clear that oil and gas interface.
- Transformer oil pillow with water: This is similar to the above, oil and gas interface is clear in thermal spectrum, but because of the density of water than oil, and water volume are usually less, so the oil water interface in oil Pillow Bottom.
- High-pressure casing as a result of media and increase the wear and tear caused by the heat: the thermal imager is characterized by defects compared with the normal casing with the overall high temperature, the temperature under normal circumstances should not exceed 1K.
- As a result of non-performing core transformer insulation caused by heat: dry-type transformers in such cases, the thermal spectrum is defective as the central part of the local temperature, the oil-immersed transformers need suspended after the imposition of a certain degree of cover-voltage test Can be observed in the core insulation damage, so the best tie in with major repairs carried out to determine the transformer.
- Transformer external connector as a result of heat caused by the bad: Transformer high and low pressure side of the round connector (for example, clamp device) is often due to improper installation or contact surface, such as aging causes bad connection, the contact resistance increases, which led to the heat, heat Spectrum can clearly see the hot fat.

As the penetration of infrared weak, and different materials, environmental factors such as temperature of the radiation rate of relatively large, so the internal transformer fault can not be all in the form of thermal imaging to accurately displayed, but also with other measurements Combination of methods, timely and accurate internal transformer was found shortcomings and anomalies for the safe operation of power grids to create the conditions. No diagnosis of what kind of comprehensive approach to the diagnosis of a variety of potential transformer fault is in full force and effect, through the power transformer on the potential failure of various types, as well as the current diagnostic methods and on-site test results can be seen:

- Latent in the transformer fault diagnosis, diagnostic methods for infrared exposed in the external and not very large volume of parts, oil and cooling systems, tank and eddy current in-house dry-type transformer fault diagnosis effective. Not only can achieve long-distance on-line diagnosis, and failure for the position, both qualitative and quantitative comparison accurate than other methods of diagnosis of superior characteristics.

- Transformer on the body's internal fault diagnosis, as a result of failures in the oil inside the body and the outside shell and the depths of me, hard to fault information passed out. As a result, in this case, infrared diagnostic method can be run by changing the load and conditions, detect changes in the dynamics of the transformer. In combination with other means of a comprehensive analysis, or in the use of fault-prone parts of laying fiber-optic infrared and other methods of monitoring and diagnosis.
- Transformer oil on the hanging after the foreign shield for using incentive infrared diagnosis, diagnostic methods and analysis of the effect and dry the same.

1.2 Infrared technology in other substation equipment fault diagnosis

- Reactor: Box local heat, cooling devices, such as oil and defects;-wave reactor, caused by vortex ring fever; reactor casing joints, and eddy current cabinet cooling device failure, and so on.
- Arrester: The most common water internal arrester is damp caused by the flashover. The valve arrester type of fault for more internal damp or parallel fault; MOA and the internal fault-usually damp (bad seal) and aging.
- Capacitor: dielectric loss increased, internal out of oil, discharge and so on.
- Circuit Breaker: bad body caused by the diversion of overheating fault, porcelain sets of internal damp insulation, dynamic contact bad, out of oil, then bad contact in the middle and static contact base bad.
- Transformers: insulation failure, and the core coil failure, failure to connect with and out of oil.
- Switches: porcelain surface pollution column plot, porcelain column cracks, insulation degradation and bad isolation.

2. Infrared technology diagnostic analysis method

Infrared detection by using infrared imaging system in general, when all testing should be part of a comprehensive scan to identify abnormal hot site; then focus on the unusual location and detection equipment for accurate temperature measurement and thermal spectra of intake ; Analysis software application for a detailed analysis to determine the nature of failure and put forward their views to deal with; reported to the diagnosis and abnormal heat spectrum.

Accurate temperature measurement should pay attention to:

① For the detection of different objects to choose a different environment in the light of body temperature.

② The right choice to launch the rate of detected objects.

③ Comparison of like with like, pay attention to maintaining the equipment with the corresponding point distance, the same position.

④ From different directions to carry out tests to derive the most value of the temperature of the hot spots.

⑤ Abnormal record of the actual equipment and heat load current phase, phase and the normal ambient temperature in the light of the body temperature.

To determine the surface temperature of law: According to the equipment measured the surface temperature control DL/T664-1999 "charged diagnostic equipment, infrared technology guidelines" and GB763-1990 Table A1, relating to the A2 table, where the temperature (Or temperature rise) more than the standard, according to the level of standard equipment, temperature, the size of the rate of loading equipment, facilities and equipment in the importance of mechanical stress to bear the size of the equipment to determine the nature of the defect, a small load on the rate of temperature rise over the next Mechanical stress or under the larger equipment necessary to strictly qualitative.

Method to determine the relative temperature difference: In order to improve the accuracy of the judgments, the current heat-induced, if the diversion of the equipment found in some of the thermal anomaly should be accurate temperature measurement, according to the formula $[(T_1-T_2)\div(T_1-T_0)]\times100\%$ calculated the relative value of the temperature difference, according to the current heat-induced devices criterion of the relative temperature difference between the provisions of equipment to determine the nature of the defect, see table 1. Table 1, T1 to the temperature of hot fat; T2 compared to the normal temperature; T0 for the environment in the light of the body temperature.

Table 1. Current heat-induced temperature difference between the relative equipment Criterion

Equipment Type	Relative Temperature Difference		
	General	Major	Emergency
SF_6 Circuit Breaker	≥20%	≥80%	≥95%
Vacuum Circuit Breaker	≥20%	≥80%	≥95%
Oil-filled Casing	≥20%	≥80%	≥95%
High Voltage Switchboard	≥35%	≥80%	≥95%
Switches	≥35%	≥80%	≥95%
Other current equipment	≥35%	≥80%	≥95%

When issued temperature of the hot spot to appreciate less than 1K, not in accordance with the provisions of Table 1 to determine the nature of the equipment deficiencies. Load factor for the small, small temperature rise, but the relatively large temperature difference, if the load conditions change, can increase the load after the current test to determine the nature of the equipment deficiencies. When the test can not be, can be tentatively scheduled for general defects, and attention to the surveillance and monitoring.

Compared with the same method:

① The same electrical circuit, when the three-phase currents symmetric (or two-phase) and the same equipment, compared with three-phase (or two-phase) addressed to the current heat-equipment sector, the corresponding temperature rise, the equipment can determine whether or not normal. If the unusual three-phase equipment at the same time, with the same loop of its kind in comparison. When the three-phase load current asymmetry should take into account the current load.

② For the same type of heat-induced voltage equipment, according to the temperature at the corresponding appreciation of the differences to determine whether or not the normal equipment. Heat-induced voltage equipment defects allowed to use the same temperature rise or to allow the temperature to determine the basis to judge. Under normal circumstances, when a similar temperature to allow temperature rise of more than 30 % should be taken as a major flaw. When the three-phase voltage asymmetric voltage should be taken into account.

Thermal spectrum analysis: In accordance with similar equipment in the normal and abnormal state of the thermal spectrum of equipment to determine whether the differences between normal.

File analysis: analysis of the same equipment at different times of testing data (such as temperature rise, temperature and relative thermal spectra), and equipment to identify trends and changes in the parameters of the rate of change in order to determine whether or not the normal equipment.

2 Infrared thermal imaging analysis samples of substation equipment

According to the Shanghai Municipal Electric Power Company at the scene in recent years, infrared detection of defects in the transformer data, out of oil casing and the magnetic flux leakage is the most common flaw running, respectively, accounting for 20% of the defective transformer and 60%. So this article from a selection of casing defects out of oil 1 case of transformer and magnetic flux leakage defect 1 case of the infrared map.

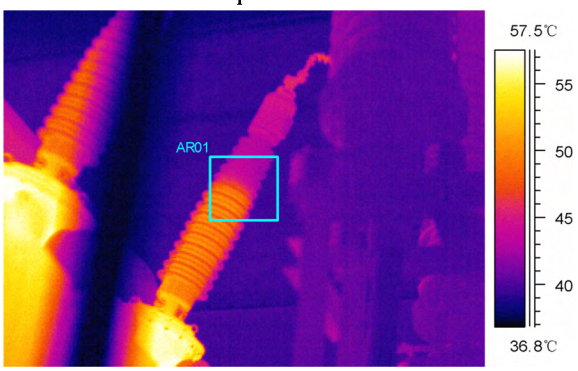

Figure 1. 110kV Transformer Casing

Name: 110kV Transformer Casing

Instrumentation: PM65

Lens Degree: 12 degrees

Fault Type: Casing out of oil, so that the casing of the central large temperature difference, reaching over 15 degrees.

Conclusion: The power failure after the inspection found that the casing of the oil-less, in the lead casing has been exposed in the air, this is a more serious defects. After refueling, the defect eliminated.

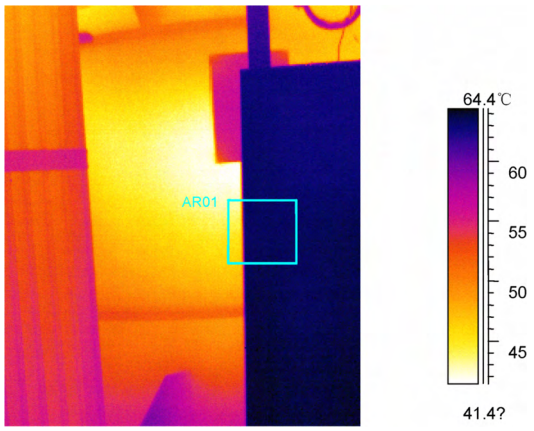

Figure 2. 35kV Transformer Middle Part

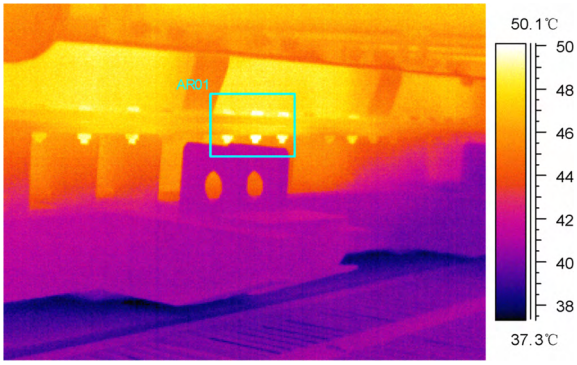

Figure 3. 35kV Transformer Bottom Part

Name: 35kV Transformer Middle and Bottom Part
Instrumentation: PM65
Lens Degree: 12 degrees
Fault Type: Transformer magnetic flux leakage.
Conclusion: Analysis of the view that the transformer there is a certain degree of magnetic flux leakage, but does not affect the normal operation of the equipment. Combined with the opportunity to repair power outages, up and down the soft shell connection Unicom, the introduction of magnetic flux leakage to earth.

3. Infrared detection and diagnosis management system

Infrared detection and diagnosis system to detect infrared-based, the use of modern information technology, network technology platform for data structures, the establishment of diagnostic detection of infrared data center, through infrared detection technology and information technology, communications, technology integration, the realization of the red Outside the detection and diagnosis of the standardization of information and network.

First of all, the establishment of infrared detection system, database diagnostics, to change the system as a stand-alone operation mode client / server model, data exchange network, will be infrared images and related information to the infrared data storage, maintenance and unified management The establishment of the future library system, experts lay a firm foundation. Infrared data on a regular basis the backup medium (CD, tape, etc.), the system provides automatic and manual backup mode, the backup cycle can be adjusted according to actual requirements.

On this basis, the establishment of the infrared detection data center:

(1) Networking deal with defects of infrared thermal imaging: a unified model of the report, the norms require the contents of the report, the realization of infrared images, data and the report of the review process, the infrared analysis of the shortcomings of network transmission, Defects found in the realization of thermal analysis to determine, processing, database people, summary and a series of systematic work, and gradually combined company MIS system defect management process.

(2) To facilitate the provision of effective information, statistical tools to enable users based on the type of equipment, the type of fault, the voltage level, the designated equipment, temperature rise, unit and time to conduct inquiries on the infrared monitoring and diagnosis of the report to statistics, and in accordance with the Temperature rise of the historical analysis equipment.

Infrared construction sites, issued related news, and provide infrared Forum, the Web site to support the station to send text messages. Support for picture messaging, code display, and so on to quote the full functionality, ease of full-time, experts in the analysis of the infrared images, and the new infrared equipment, the use of new technology to provide a platform to discuss.

(3) To amend and improve the Shanghai Municipal Electric Power Company infrared detection diagnosis and management of the technical work of the norms.

4. Conclusion

With the power of reform and opening up the deep and electricity market further, various types of equipment, power supply put forward higher requirements. In order to ensure the safe operation of power supply equipment, business-to-electricity power supply equipment to improve and enhance adopted a series of corresponding measures. However, the sudden failure of equipment still exist, especially in equipment, load and weather changes in the size of the mutation, the fault is more prominent in this situation, the electricity supply sector will need to gradually raise their level of management, who voted to increase scientific and technological , Research and supply of equipment to address the problem, change from passive to active monitoring of the treatment.

Infrared temperature measurement work, so that the operation is not in power, be able to run the equipment to keep abreast of the situation, in order to find equipment, to develop countermeasures to provide first-hand information, so that the defects of early detection, early analysis As early as the elimination of the use of technology in a timely manner after the discovery and elimination of the bad switches, the damage to the flow, cable head-end line of the end of the surface discharge, damp spark arrester within a number of shortcomings, to avoid the accident and more, greatly enhance their own power supply Economic and social benefits. On this basis, the company has developed the "Shanghai Power supply equipment maintenance, pre-test and calibration cycle", a reasonable extension of the maintenance cycle of the equipment has greatly enhanced the reliability of power supply.

In recent years, sum up experience, in order to better promote the work of infrared detection, diagnosis, we,

through infrared technology and information technology integration, so that the infrared detection and diagnosis and better management of the systematic establishment of infrared detection data center, Realized the sharing of resources, improved efficiency, so that the infrared to a higher level of management, and for the future were satisfied defect management processes and the establishment of expert database system to lay a solid foundation; infrared work to open up a forum for better Infrared offer advice and suggestions to carry out the work, can also invite experts to defect infrared pulse, increased the level of technical analysis and efficiency so that the infrared detection technology to better equipment, and power companies in Shanghai enterprises have been Good promotion and application, in order to improve the reliability and security of electricity supply companies to ensure the safe operation of equipment lay a solid foundation.

References

[1] Jiping Wu, Yuenian Li. Infrared imaging devices used in electrical equipment fault diagnosis. Electrical Equipment, 2006.

[2] Jie Yan. Infrared detection and diagnosis equipment management system in the run charged Detection. Power sustainable development and information technology papers.

[3] Jianli Zhang, Nianguang Wang.. Infrared temperature measurement technology in the power transformer fault diagnosis.