Switchgear fault detection and diagnosis system based on digital and shape combination

Xiaoyu Zhou

School of North China Electric Power University, Hebei, China

Abstract. Switchgear is a very common power equipment, and the detection and maintenance of its fault is very important. Only to ensure the reliability of switchgear can ensure the normal operation of the entire power system. In order to reduce the influence of the harm to power system fault, we want to make a system for real-time monitoring of it, the switchgear in internal fault occurs, the system can quickly alert and locate the fault location. Maintenance personnel can quickly take some protective measures to furthest reduce the harm of other electrical equipment and power workers. This project develops a set of switchgear fault monitoring and diagnosis system with the help of four-star time difference positioning method and the organic combination of data and graphics by LABVIEW and SOLIDWORKS. In addition, according to the simulation of heat conduction at the discharge position, the temperature measuring device is used as an auxiliary device to monitor the discharge position, distinguish the temperature difference between the fault point and the normal operation of the equipment, then find the fault point location.

Keywords: 3D model; Discharge simulation; Four-star time difference location method; Heat conduction; Fluent.

1. Introduction

By actual observation and measurement, we established a three-dimensional model of switchgear, and imported it into LABVIEW, realizing the simulation of the discharge point of failure. Then the four-star time difference positioning method was used in the internal space to achieve positioning function, using the sensor to receive the vibration frequency and waveform of mechanical wave generated by the simulation of the discharge point, which is in the internal space we set four sensors and determine its position coordinates, then assume that the distance from the discharge point to the sensors is unknown quantities. Based on a sensor, the x, y and z coordinates of the unknown discharge point are expressed by the other three distance difference and the time difference of electromagnetic wave propagation. Then the linear equations are solved by matrix, and finally the discharge point coordinates are obtained. In addition, we simulated the temperature distribution of discharge position after overheating in FLUENT, which can assist temperature monitoring instruments, such as thermal infrared imager, to monitor the fault point, so as to improve the accuracy of fault point location.

2. The establishment of model and generation of discharge point

2.1 3D model of switchgear

Through the measurement of an actual switchgear, we established the basic model of the switchgear. The switchgear we used is an indoor metal armored shift switch equipment (KYN28A-12) high voltage incoming line cabinet.

Through certain simplification, we used SOLIDWORKS to establish the 3D model of the switchgear. The figures as shown below:

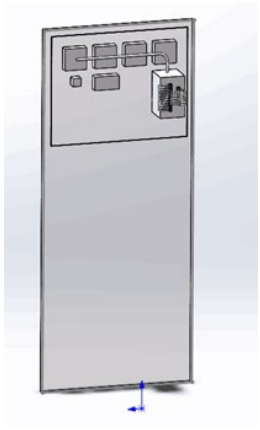


Figure 1. Switchgear door

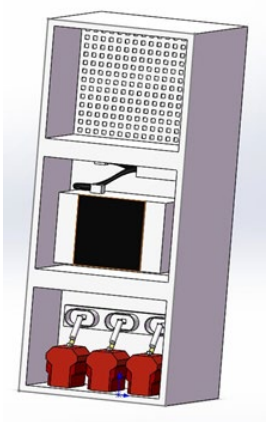


Figure 2. Switchgear body

For better visual effect, we set the cabinet door of the switchgear as transparent. At the same time, we increased a certain distance between the door and the cabinet body, as shown in the picture below:

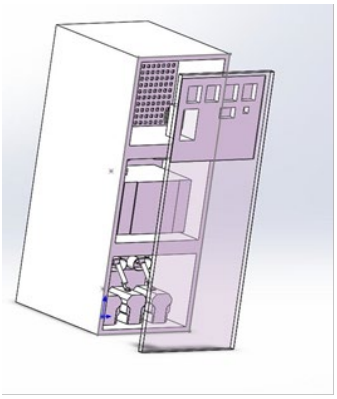


Figure 3. 3D model of switchgear

2.2 Generation of discharge point

We use the event structure and the while loop of LABVIEW to simulate the generation of random discharge point position in the busbar chamber when the fault occurs, attaching its position coordinates.

The program block diagram of the design process and the discharge point position display diagram are shown below.

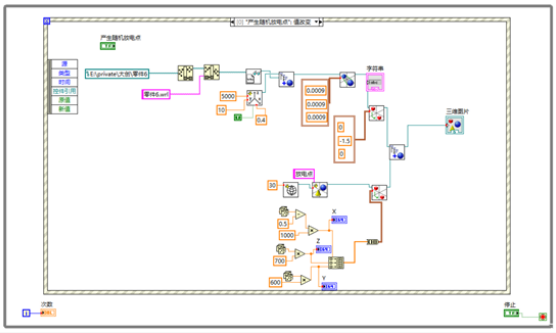


Figure 4. LABVIEW program block diagram

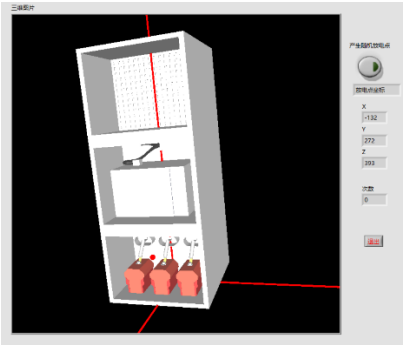


Figure 5. Discharge point position display diagram

3. Location of discharge point

According to the analysis of the actual problem, we decide to use four sensors to locate the discharge point. Compared with three sensors, the advantage of using four sensors to locate the discharge point is that the analytical solution can be obtained directly, and there is no need to carry out tedious iterative solution.

Based on time Difference of Arrival Method (TDOAM), the switchgear busbar chamber is simulated as a cube. Taking one of the vertex angles as the origin, the three-dimensional coordinate system as shown in the figure is established. The partial discharge source is represented by P(x,y,z), and each sensor is represented by S1(x1,y1,z1) , S2(x2,y2,z2) and S3(x3,y3,z3) respectively.

As shown in figure 6:

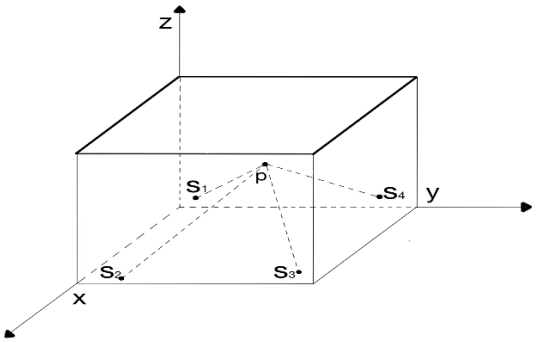


Figure 6. Sensor setting location

Using the sensor to receive the vibration frequency and waveform of mechanical wave generated by the simulation of the discharge point, and imported it into LABVIEW software. The main function of LABVIEW platform is to complete the development of virtual instrument. In the data acquisition, data analysis, the analysis of the complex algorithm and many other aspects, it also has a powerful function. Besides, it has the advantages of undertaking flexible programming, having friendlier interface. Operations personnel can also adjust the content of the interface according to their own

subjective intention, and realize the remote network communication beyond the limits of space. It can be considered that it has important application value in automation, measurement, control and other fields.

Taking sensor S1 in figure 5 as the reference sensor, τi1 represents the estimated time delay of ultrasonic signal received by sensor i and sensor 1(among them i=2,3,4), and so on. However, due to the complex internal structure of the switchgear, the wave propagation will be influenced by many times of refraction and reflection, as well as the propagation medium. After the programming of the four-star time difference positioning method, the deviation between the positioning result and the actual situation increases, which is to say that the result is not ideal. Then we use heat conduction in the internal solid of the switchgear to carry out the auxiliary state monitoring.

4. Simulation of local overheating

Partial discharge occurs in the switchgear not only ultrasonic signal, but also local overheating phenomenon. Therefore, we can judge the discharge point position by using infrared thermal imager according to the temperature distribution diagram of solid heat conduction inside the model.

The measure we took is imported the 3D model into the FLENT software and established the grid for it. The grid partition can be understood as a complex entity model is divided into several simple model, and these simple individuals are interconnected and constrained by each other, which constitute the whole structure. Therefore, by solving these simple model structures, the overall trend can be obtained, and then the heat conduction law also can be found.

The grid diagram is as follows:

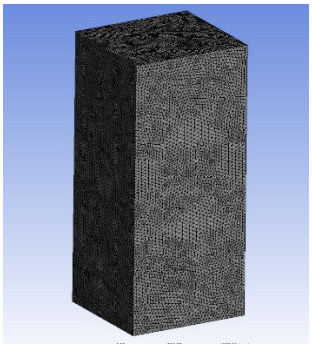


Figure 7. Grid diagram display of switchgear model

The specific method is to simulate the conduction process of partial discharge overheating.

Setting the location of partial discharge and its initial temperature. To study the conduction of temperature in solid medium, we selected three different positions to display the temperature distribution.

The simulation diagram of heat conduction is as follows:

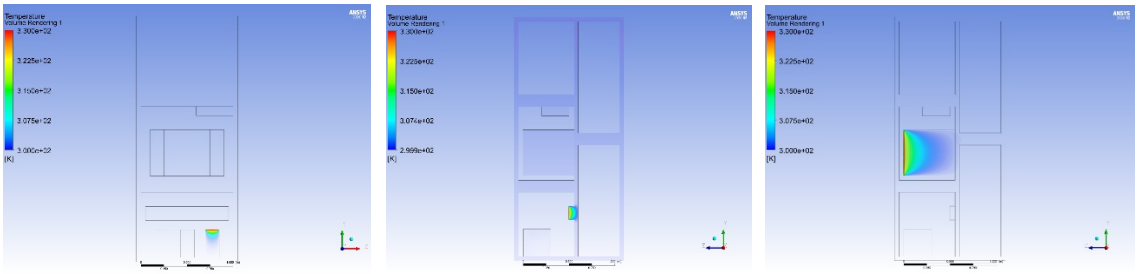


Figure 8. Solid heat conduction process simulation

According to the temperature distribution of heat conduction, it is not hard to see, in the process of heat conduction is diminishing: the discharge point is characterized by the highest temperature and longest duration. According to data shows, temperature rating of the power equipment during normal

operation can't more than 40 degrees Celsius, and power equipment's temperature after the failure rises 5~30 degrees Celsius. So, the temperature of discharge point is the highest when failure occurs. Thus, we can choose to use the temperature detection device, like infrared thermal imager, to monitor the highest temperature, that is, the location of the discharge point.

5. Conclusion

In order to ensure the normal operation of power system equipment, switch equipment fault monitoring is very important. Timely detection and maintenance of power equipment fault can save a lot of manpower and material resources. The project emphasis on failure detection technology of discharge point: through two aspects, on the one hand, using real time monitoring system to realize the preliminary detection and positioning. On the other hand, temperature measuring device, as auxiliary equipment, accurately locate the discharge point position to further improve the efficiency and accuracy of fault detection and discharge point positioning. Finally, it can realize the high voltage electrical equipment fault early warning, which is of great significance to ensure power supply safety.

References

[1] Hou Changming. Partial Discharge Detection and Fault Analysis of GIS Equipment [J]. Electronic Testing,2013(12):54-55.

[2] LI Jianjun. Research on four-star Time difference location algorithm [J]. Electronic Countermeasures Technology, 2004(04):3-6+15.

[3] Zhao Hongshan, GAO Yufeng. Fault detection and analysis of GIS equipment based on vibration feature estimation [J]. High voltage apparatus, 2020, 56(06): 114-120.DOI: 10.13296/j.1001-1609.hva.2020.06.017.

[4] Zhang Gang, Wang Yi-mei, Li Yun-song. Multi-functional formaldehyde detector based on LabVIEW platform [J]. Shandong Industrial Technology, 2019(2):3.

[5] Wang Zizhi, Wang Fuliu, Yu Tao, Zhang Jianwei, Liu Peng. Aviation battery charging and discharging temperature monitoring system design [J]. Journal of aircraft maintenance and engineering, 2020 (03): 63-65. The DOI: 10.19302 / j.carol carroll nki. 1672-0989.2020.03.018.