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Analysis and Treatment of Typical Problems of GIS Circuit Breaker

Bing Shen, Shaobin Jiang, Zhangxiu Li, Guozheng Li

Ertan Power Plant Maintenance Department, Yalong River Basin Hydropower Development Co., Ltd., Chengdu, China

Email address:
861409758@qq.com (Bing Shen)

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Abstract: With the development and progress of society, the demand for electric energy is increasing day by day. The number of hydropower stations has increased dramatically. In the large-scale hydropower stations and substations currently under construction, GIS high-voltage switch stations have gradually replaced traditional high-voltage switch stations due to their advantages of arc extinguishing and insulation performance, low floor space and high reliability. The GIS breaker body and the operating mechanism of the GIS breaker, or other components of the GIS switch station, are subject to various reasons such as design, manufacture, installation, commissioning, operation and maintenance. Frequently, the GIS breaker leaks, the circuit breaker refuses to move, the operating mechanism cannot store energy normally, and the closing time is not easy to measure. These phenomena pose a serious threat to the safe and stable operation of the power system. Such typical phenomena of GIS circuit breakers deserve our consideration of inquiry, analysis and summary. Find the root cause of the failure and propose the most effective improvement. This paper proposes and solves several typical faults during the installation, commissioning, operation and maintenance of GIS circuit breakers. Provide reference for the fault analysis and processing of GIS circuit breakers in the future.

Keywords: GIS, SF6 Gas Leakage, Circuit Breaker Rejection, Separation Gate Time

1. Introduction

Since the practical use of GIS equipment in the 1960s, it has been widely used around the world. GIS is widely used not only in the fields of high pressure and ultra high pressure, but also in the field of UHV. Compared with conventional open substation, GIS has the advantages of compact structure, small floor space, high reliability, flexible configuration, convenient installation, strong safety, strong environmental adaptability and small maintenance workload. Gradually replace the traditional high voltage switchyard [1]. The operating state of the GIS circuit breaker directly affects the safe and stable operation of the power system. In recent years, with the increasing use of GIS circuit breakers, the typical cases of failures have gradually increased. GIS high-voltage switchgear in the process of casting, due to installation, commissioning, operation and maintenance, there are often phenomena such as GIS breaker air leakage, circuit breaker refusal, the operating mechanism can not normally store energy, the closing time is not easy to measure, etc.. This typical GIS breaker failure is worth considering, analyzing and summarizing. Finding the root cause of the failure and proposing the most effective treatment measures deserves attention and reference.

2. Some Typical Problems During GIS Switching Station Installation and Debugging

2.1. Location of SF6 Gas Leakage Fault

SF6 gas is used as an insulating gas for GIS switching stations. When GIS installation is completed, a certain amount of SF6 gas must be filled. According to the GB 50150-2006 "Standard Transfer Test Protocol for Electrical Equipment Transfer Test for Electrical Installation Engineering", the GIS switching stations should be detected. Under the current conditions which the method of fault management is quite mature in china [2]. The key points and difficulties are the location of leakage points. After the GIS installation is completed, SF6 gas will be filled. According to the regulations, local dressing will be used to wrap the GIS inflatable interval, and then the leak detector will be used for leak detection. When the leak point is detected by leakage detection of SF6 gas leaks, or if it is discovered through daily inspection work that the pressure of the SF6 gas pressure gauge of the GIS switch station is significantly reduced and the on-line monitoring pressure gauge finds that there is a gas leak, The traditional method is to use high concentration soap foam method and halogen detector and other methods.

Soap foam method is to apply a layer of high concentration of soap foam to the key part of the initial diagnosis of leaking gas. When there is a gas leak, bubbles can be clearly found to find leakage points. Although this method is simple, does not require instruments and is easy to implement, it can only be easily found in places where the amount of air leakage is large. This method can only be qualitatively referenced and can not quantitatively assess the size of the leakage amount, which is relatively inefficient. The halogen detector is a leak detector made of halogen utility. [3, 4] Metal platinum wire undergoes positive ion emission at a certain temperature. When a halogen gas leak is detected, positive ion emission will greatly increase, so it can be used as SF6 gas. Quantitative leakage, In addition, the volume is small, the power consumption is low, and it can be detected electrically. However, when it is used to find specific leakage points, the workload is large and the performance is unstable.

The new positioning method uses SF6 gas leakage infrared imager, and SF6 molecules have strong absorption characteristics in the infrared spectrum. The detection instrument scans the measured object by sending out an infrared laser. The presence of SF6 gas leakage and its severity is determined by detecting reflected infrared light. When SF6 gas leaks in the detection area, the infrared light reflected to the detection device will be drastically reduced, and the leakage location can be easily detected and the leakage detection efficiency is high. When conditions permit, it is recommended that GIS switching stations can purchase SF6 gas leakage infrared imagers for the location of SF6 gas leakage fault points, which can greatly shorten the time for fault handling, and can be used in the daily inspection process to find problems as soon as possible. It provides a strong guarantee for the safety and stability of the switching station [5].

2.2. GIS circuit Breaker Connection Problem Causes Difficulty in Measuring the Closing Time

According to the GB 50150-2006 "Standard Transfer Test Procedure for Electrical Equipment Transfer Test for Electrical Device Installation Engineering", the circuit breaker must be measured. [6] For many hydropower stations at present, there is no isolation switch between the high-voltage side line of the main Transformer and the GIS incoming circuit breaker, and during the maintenance of the substation GIS, both ends of the short circuit breaker need to be put on the ground knife to ensure maintenance safety. However, at present, the time of measuring the short-circuit device splitting is measured. The circuit breaker required by the wiring of the measuring instrument must be grounded at one end and suspended at one end, as shown in Figure 1. This leads to the difficulty of measuring the closing time of the GIS short-circuit device.

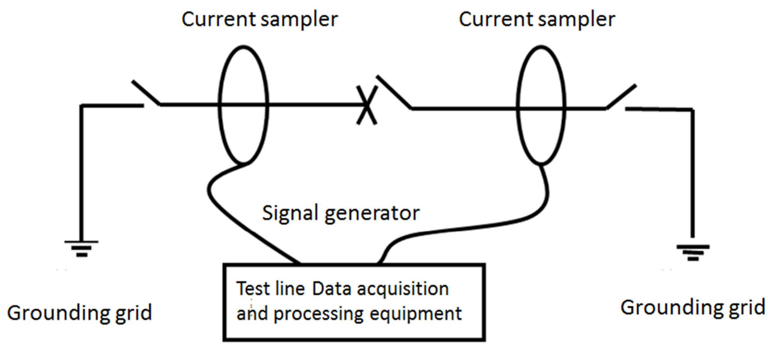

Figure 1. *The opening and closing time measurement principle of the circuit breaker both side connected to the earth.*

For the safety of substation GIS maintenance during maintenance, the new measurement principle can be used to measure the current test instrument when the circuit breaker is grounded at both ends. When the two ends of the circuit breaker are grounded, the principle of electromagnetic induction can be used. After the two ends of the circuit breaker are grounded, a closed loop is formed [7]. Two pincer induction coils are inserted into the loop, and one is an AC power supply with a high frequency input of the coil. Another current sampling coil is collected by means of a closed loop. When the circuit breaker is closed, the current sampling coil collects the inductive current, and the inductive current can not be collected when the circuit breaker splits. This principle can be used to determine the opening and closing state of the circuit breaker to measure the closing time. After the inductive electromotive force collected by the current sampling coil enters the signal collection box, it is shaped and filtered by the CPU for digital filtering, FFT analysis, and the opening and closing valve values are compared. At the same time, the collected inductive electricity flows into the line waveform recording wave. When the current waveform begins to be established, it is the moment when the contact leads, and when the current waveform begins to disappear, it is the moment when the contact breaks off. Thus, the closing time can be tested under the condition that both ends of the circuit breaker are grounded.

For the main Transformer high-voltage side line and the GIS incoming circuit breaker, there is no isolation switch problem and it is difficult to measure the separation gate time. Through comprehensive analysis and treatment, a hydropower station in Sichuan Province of China adopted the method of disconnecting the connection between the high voltage side casing outlet line of the main transformer and the casing inlet line of the GIS. By unlocking the connection between the main variable high voltage side sleeve line and the GIS inline sleeve, and closing the grounding switch of the GIS circuit breaker, the grounding plate connected by the grounding switch and the GIS housing is unlocked. This provides a one-person suspension for the GIS incoming circuit breaker and a section of ground conditions, which provides the possibility for the wiring of the test instrument. According to the on-site test of this Hydropower Station, this method is found to be feasible. However, due to the regular work in the future, it is also necessary to measure the circuit breaker closing time, which leads to the need to untie the connecting line on the main variable high voltage sleeve every time the separation closing time is measured. In the long run, the main variable high pressure sleeve will inevitably cause adverse effects. The following solutions can be used:

The first is that in the design of a power plant or substation in the future, an isolation switch can be installed between the main variable high voltage sleeve and the GIS incoming circuit breaker to provide convenience for future operation and maintenance [8]. For those that have been installed and completed, they can be considered for rectification later. Install isolation switch. Secondly, the above new measurement method can be used. In the future, only the main variable high voltage sleeve line can be directly grounded using the ground line and then the ground switch of the GIS incoming circuit breaker can be closed, thus forming the conditions for grounding both ends of the circuit breaker. This eliminates the need to remove the main Transformer's high voltage Bushing grounding line.

2.3. Refuse of CT30 Electric Spring Operating Mechanism

The CT30 electric spring operating mechanism is widely used in 220kV and below power supply systems. At the actual work site, the most common circuit breaker failure encountered is generally the circuit breaker rejection problem [9, 10], by means of the working principle of the CT30 model fault circuit and the circuit breaker rejection phenomenon encountered by some large hydropower stations in China, the cause of failure and the solution to the failure of the CT30 electric spring operation mechanism are put forward, providing reference for similar problems in the future.

Short circuit breaker refusal is caused by a variety of reasons. For circuit breaker maintenance personnel, the general control loop and other electrical reasons caused by the fault is relatively easy to solve, and the real trouble for maintenance personnel is caused by the internal mechanical cooperation of the operating mechanism. This paper only aims at the failure caused by the internal mechanical cooperation of the operating mechanism. The refusal of circuit breakers is mainly caused by the following aspects:

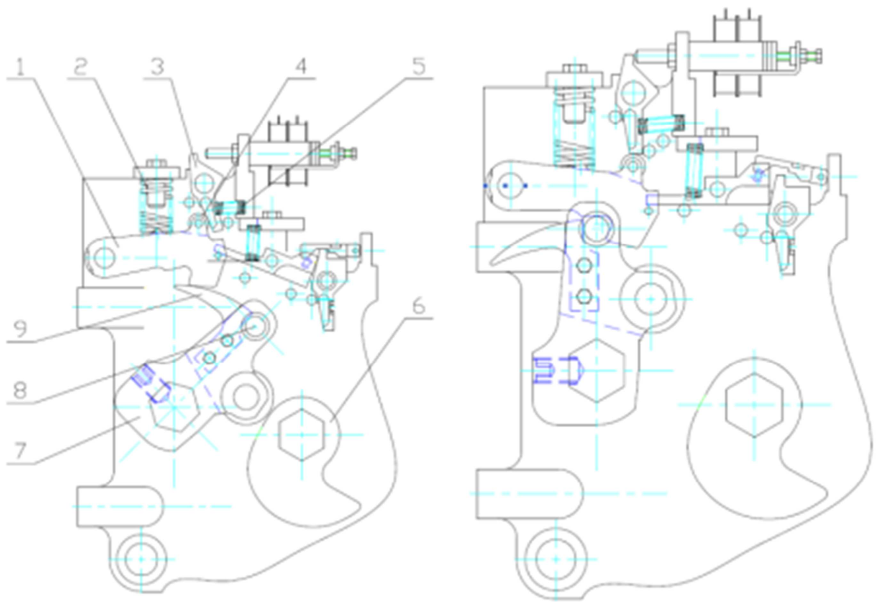

Figure 2. *CT30 type circuit breaker tripping state diagram (left) and closing state diagram (right).*

The names of the parts in Figure 2 are: 1-closing brake holding switch, 2-reset spring, 3-separation switch, 4-roller, 5-reset spring, 6-cam, 7-arm, 8-axis, 9-support pieces. CT30 type electric spring operating mechanism is mainly maintained by the frame, sub-(combined) brake spring, energy storage motor, Buffer, sub-(combined) brake electromagnet, and cam, ratchet, large (small) arm, sub-(combined) brake, piston rod, shaft Parts and components such as pins. Under normal circumstances, as long as the closing spring does not have energy storage, the energy storage motor will give the closing spring energy storage, and the storage energy of the separation spring depends on the energy of the closing spring. When the closed electromagnet receives the closing signal, it is charged, and the active iron core of the closed electromagnet absorbs, driving the switch guide rod to impact the switch, and hitting the gate; Close the switch clockwise and release the storage energy to keep the switch; The storage can keep the switch rotating counterclockwise to release the clip, and the ratchet rotates counterclockwise and drives the ratchet shaft to rotate clockwise so that the cam pushes the small arm in a clockwise direction, driving the lever to make the circuit breaker body quickly close [11, 12]; The small arm rotates clockwise while driving the large arm on the arm shaft to rotate clockwise and compress the brake spring energy storage for the separation operation. In the whole process of closing, according to the closing process, the closing time of the mechanism is a dynamic response process, that is, the over-charging and falling time of the inflection arm must be greater than the sum of the recovery time of the closing holding brake and the recovery time of the separation brake. If otherwise, There will be rejection. The key points that affect this time lie in the following places: First, due to the unsatisfactory design size or the poor cooperation of the mechanism during installation, the gate size is deformed, and it is impossible to maintain the closing state, and the gate is automatically divided; Second, the reposition spring 5 stiffness coefficient is insufficient, resulting in too long recovery time; Third, the sufficient stiffness coefficient of retaining the brake spring causes the over rush and falling time of the inflection arm to be less than the sum of the recovery time of retaining the brake and the recovery time of splitting the brake spring, resulting in the problem of rejection.

Solution: for the first reason, unscrew the opening and closing center of the dice and replace the qualified opening dice. This method is adopted at the Tongzilin Hydropower Station in Panzhihua, Sichuan Province, China. The replacement of the circuit breaker operation mechanism solves the problem of rejection. In the second and third cases, replace the reset spring or install a certain thickness of the gasket above the reset spring. The thickness of the gasket depends on the actual situation of the spring. In the case of uncertainty, the principle of gradual thickening can be passed. After replacement, test and verify, A GIS switch station adopts 1 mm thick gasket at the end of the small engine spring and the positioning hole space to increase the pressure of the resetting spring, and the rejection phenomenon is eliminated.

3. Reflections on Typical GIS Problems

The problems encountered in GIS can generally be avoided from the aspects of design and installation. For example, the separation gate time is difficult to measure. At the time of design, a grounding switch can be installed between the main change and the GIS feed switch, which can better implement the combination of the construction pipe and facilitate future maintenance. Some of the equipment did not meet the requirements due to the design, resulting in major defects during commissioning, such as leakage, rejection, etc.; There are also many problems due to the non-conformity of the installation process during installation, resulting in poor AC pressure resistance and even breakdown, which can be avoided. In the future equipment casting, factory acceptance, installation process grasp, transfer tests should be carried out according to the requirements, so as to avoid greater losses in the later period. In addition, with the development of sensor testing precision, on-line monitoring technology and so on, the use of new science and technology and test instruments provides great convenience for work and improves work efficiency. We should keep pace with the times and use new technology and means to help solve the failure of GIS circuit breaker.

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