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The Reliability Research for Integrated Integration Smart Pole Top Breaker

Yuting Dong, Lin Fu, Honglian Zhou, Jianbing Fan, Erbiao Zhou, Bin Du and Zhongzheng Li

State grid of XinJiang economy and research institute, Urumqi 830011, Xinjiang Uygur Autonomous Region, China.

119326602@qq.com.

Abstract

To improve the quality of power supply and supply, and at the same time improve the quality of service to power users, the integration of primary and secondary equipment is the only way. Given the problems existing in the on-column switch, the high reliability of the intelligent on-column switch integrated in the first and second integrations has been deeply studied. One part has improved the traditional on-column switch and operating mechanism design, effectively solving the condensation. Water, sealing and mechanism jamming; the second part is designed by integrating FTU function, using modern sensing technology to realize the all-round condition monitoring of the on-column switch; the first and second integral parts unify the standard interface and enhance the column The level of integration of the upper switch. The implementation of the project will effectively promote the integration process of primary and secondary equipment in the distribution network, and improve power quality and reliability of power supply.

Keywords

Reliability, Smart breaker, Distribution network.

1. Introduction

With the continuous expansion and deepening of the transformation of China's urban network and rural power network, based on the improvement of power supply reliability and power supply and consumption indicators, it is required to continue to improve the quality of power supply and supply, and at the same time improve the quality of service for power users. To achieve the integration of primary and secondary equipment.

One of the main switchgear for distribution network automation is the 10 kV outdoor column switch, which enables the stability and high reliability of the distribution network automation system. However, for the moment, there is still a long way to go to realize the integrated integration of the primary and secondary switches on the column, which is reflected in the following three aspects.

1) On-column switch body: ① low reliability, the current on-column switch operation accuracy is less than 22%, the reason is that the sealing material aging water, causing mechanical corrosion failure and secondary terminal row moisture short-circuit fault, causing malfunction; ②Difficult to install, improper installation of the switch on the column may cause damage to the sealing of the device; ③ It is difficult to maintain, there are a large number of switches on the distribution grid column, and the switch on part of the column is completely sealed, which makes it difficult to measure the internal condition of the equipment.

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2) Supporting feeder terminal FTU: ①Functional modules are scattered, easy to break down and inconvenient to maintain; ②Due to the lack of functions, single design, and little data collection information, it is unable to meet the requirements of state monitoring, such as the current of switching coil cannot be monitored. ③The protection level is not high.

3) First and second integral integration: ① Device interface mismatch, poor compatibility, interchangeability, and expansibility; ② The complete set of equipment has more parts and is more difficult to install; ③The first and second equipment manufacturers often have liability disputes.

To sum up, the study of a high-reliability primary and secondary integrated intelligent switch on the post has become an effective way to improve the intelligence and integration of the switch on the distribution grid post, as well as an important development direction to improve the operation and maintenance level, power quality and power supply reliability of the distribution network.

2. High-reliability improvement strategy for switch on the primary column

2.1 Switch body structure design

The traditional switch operating mechanism room on the column is located on the front side, and the cover plate is sealed by a sealing ring. The sealing ring on the front side is easy to age due to direct sunlight and rain, which will affect the reliability of the switch body for a long time. In this paper, the cover plate of the switch mechanism on the column is designed to the bottom of the box body. The shell is made of integral die-casting to avoid the aging of the sealing ring caused by direct sunlight and rain. The insulation sleeve is made of composite insulation material with strong uv resistance and hydrophobicity. The switch body on the column adopts fully insulated outgoing wire, and the operating mechanism is sealed in the mechanism room and located directly below the switch box. The protection level is designed according to IP67, which can effectively improve the reliability of the switch body. Fig 1 is the schematic diagram of the improved switch body structure on the column.

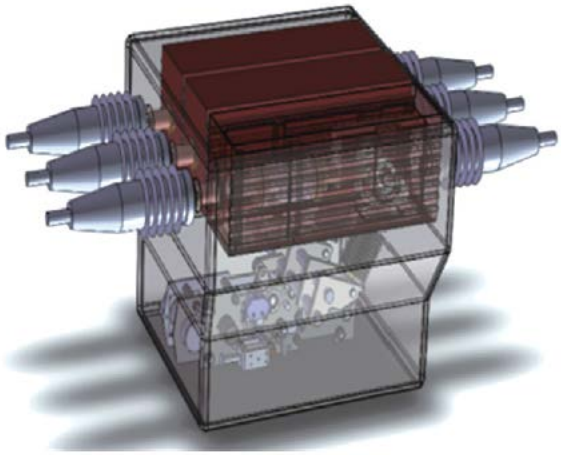

Fig. 1 The structure diagram of the improved switch body on the column

2.2 Shell design.

The switch shell on the column is made of 06Cr19Ni10 stainless steel with a thickness of 3mm. The protection level of the box body and the mechanism room conforms to the provisions of gb4208-2008. After the shell is finished, the surface is painted with spray paint, which has an effective measure of double anticorrosion and can effectively improve the corrosion resistance of the switch on the column. Fig 2 shows the design of the improved switch housing on the column.

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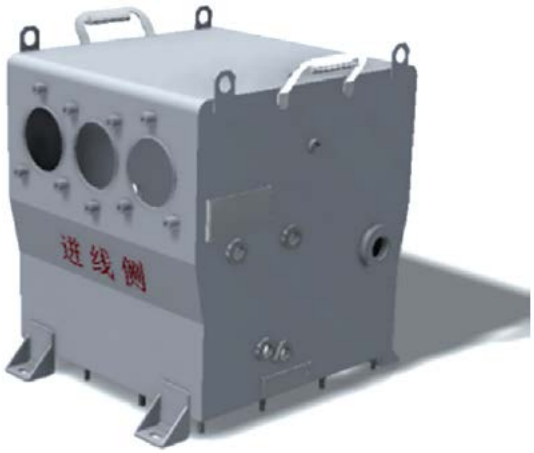

Fig. 2 Design of switch housing on the column

2.3 Operation panel seal design

The switch panel on the column is designed with a clear and reliable switch position indication. The switch opening and closing position and the spring mechanism energy storage indication are clear and easy to see. Operating switch manual opening and closing handle and manual energy storage handle devices have clear and permanent marks. Operating handle axis adopt labyrinth seal, that is, set several lined up around the axis of rotation ring seal tooth, tooth and tooth form a series of river closure gap between with expansion of cavity, the sealed medium in the generated when the winding through a maze of clearance throttle effect and achieve the effect of leakage resistance, which can effectively improve the reliability of sealing switch ontology. Fig 3 is the schematic diagram of the front of the switch on the column.

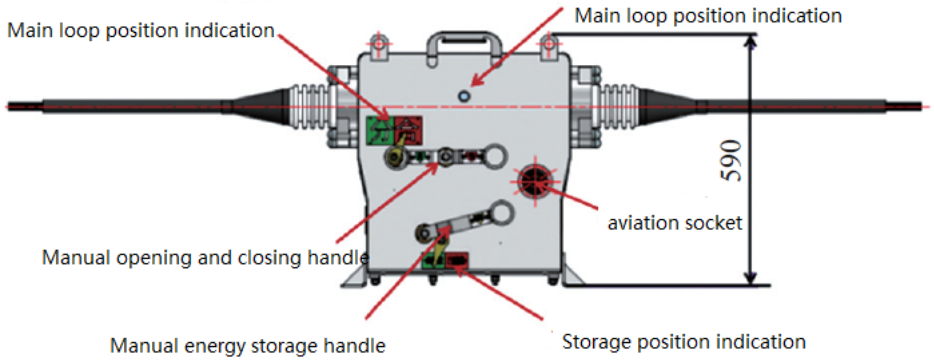

Fig. 3 Schematic diagram of switch front of column

The rotating shaft in this paper adopts a labyrinth seal, so it is necessary to analyze its seal performance. The calculation of leakage of the labyrinth seal needs thermodynamic analysis, and the process is complicated. Under the influence of inertia, when the gas passes through the maze, the fluid section will shrink, and after the contraction, the minimum area S_c of the gas is:

$$S_c = C_C S \tag{1}$$

In the formula, S is the area of the labyrinth orifice; C_C it is the contraction coefficient of gas.

The velocity of gas also changes when it passes through the orifice, and the actual velocity v_c is:

$$v_c = C_d v \tag{2}$$

In the formula, v is the gas velocity under ideal state; C_d is the velocity coefficient.

According to equations (1) and (2), the actual flow through the mouth of the maze is Q:

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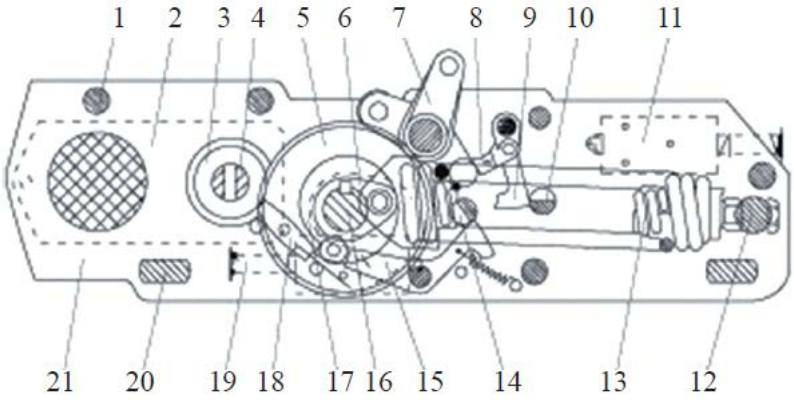
$$Q = C_C C_d S v \tag{3}$$

In the formula, $C_C C_d = \alpha$ α is the flow coefficient of the maze orifice.

α is related not only to the shape of the gap, the shape of the addendum and the roughness of the surface but also to the pressure ratio and Mach number of the compressed gas. For sharp teeth, α it is generally 0.7; For circular teeth, it α is usually 1. Therefore, when the labyrinth seal design is adopted, it usually adopts the structure design of flow channel length and tooth center to increase the resistance and reduce the leakage of gas.

2.4 Operating mechanism design

Spring operating mechanism is a mechanical operating mechanism with spring as an energy storage element, its structure is shown in fig 4. The energy storage of the spring is completed using the motor through the reduction device and is maintained in the energy storage state through the locking system. When broken, the lock release energy with the help of magnetic release, spring, through the mechanical transfer unit to make contact movement. Spring operating mechanism advantage is significant, but in the long-term use, the spring operating mechanism failure rate is very high, accounting for more than 50% of the total switch fault on the column. The main reasons for the failure include the breakdown of the opening and closing coil and the unreasonable design of the trip mechanism.



1 – support rod;2 – motor; 3 – pinion;4 – energy storage shaft; 5 – big gear;6 – hanging spring crank;7 – output crank; 8 – stop; 9 – brake stopper;10 – brake axle;11 – brake release;12 – suspension spring shaft; 13 – closing spring;14 – closing half shaft;15 – closing pawl; 16 – spindle;17 – wheel;18 – clutch plate;19 – closing release20 – shores; 21 – plywood.

Fig. 4 Operating mechanism structure

For the former, in the FTU design below, the current monitoring function of the shunt and close coil is added. For the latter, the rotating shaft of the traditional tripping mechanism is fixed on the mechanism by using two shaft sleeves. In this design, the connection between the rotating shaft and the support of the mechanism is improved to the connection between the shaft and the bearing. The friction force is greatly reduced, the long-time operation is not stuck, and the reliability of the operating mechanism can be effectively improved.

3. Study on high reliability of secondary FTU

3.1 FTU integrated function integrated design

At present, the switch FTU function modules on the column are scattered, prone to failure and inconvenient to maintain. The FTU energy integration scheme designed in this paper has the functions of distribution automation measurement, protection, single-phase grounding, harmonic measurement and equipment status monitoring. It includes the following aspects.

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1) Integrated measurement, protection, and other conventional FTU functions. In terms of measurement function, it mainly realizes remote measurement, remote signal, remote control function and collection, measurement and calculation of electronic current and voltage transformer. In terms of protection function, the protection logic can be flexibly configured in the form of three-stage current protection and voltage-time protection.

2) Integrated single-phasese earth fault determination function. For the small current grounding system, the method adopted in this paper is to improve the FTU acquisition frequency, integrate the recording function, and adopt the combination of steady-state and transient state to judge the grounding fault. Based on the massive line operation data collected in the field, the fault model, operating condition model and identification algorithm of the line are established and verified, and the expert system is established to realize the identification and fault location of the line operation condition.

3) Integrated harmonic measurement and analysis function. FTU monitors load harmonics in the boundary online. When the harmonics reach the parameters set by the user, the circuit breaker will alarm or break. This function can effectively prevent the boundary harmonics from affecting the power supply quality of the entire grid, and prevent the equipment from being damaged due to harmonics.

3.2 FTU omni-directional condition monitoring design

The operating mechanism in the switch on the column is the main part that is prone to failure. It often occurs in the open and close coil burning, motor plugging and mechanism stuck, and other accidents. The FTU designed in this paper monitors the operating current of the open and closed coil, the rotational current of the energy storage motor, temperature, and humidity data, etc. It can analyze the ripple change of its data and simulate the fault evolution. This design can arrange targeted maintenance or inspection on the expected fault, eliminate the possibility of the fault, nip the fault in the bud, can effectively improve the reliability of switch operation on the column.

1) Open and close coil current monitoring

The block diagram of its monitoring principle is shown in fig 5. In the figure, the operating power supply used for opening and closing the output operating mechanism passes through the hall sensor of tr0229-lb5 series and determines whether the signal collected is opening or closing based on the CPU operation. Hall sensor is powered by 5v voltage, and the output analog signal is directly connected to AD channel inside MCU after the signal conditioning circuit such as anti-aliasing filtering and amplitude adjustment.

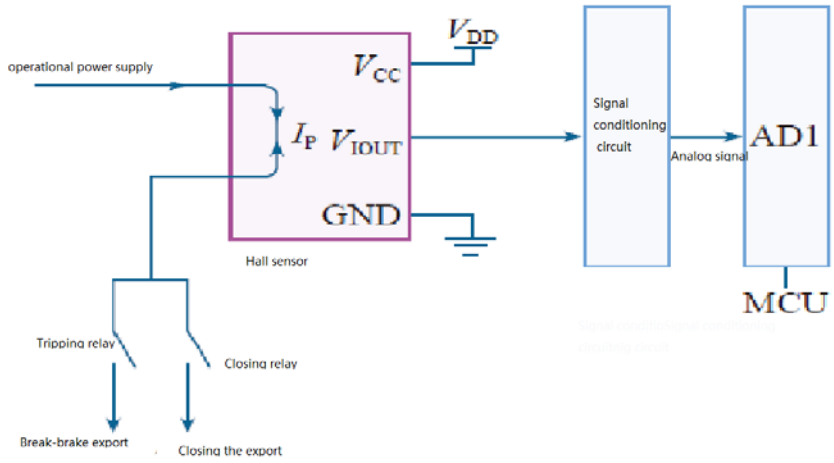

Fig. 5 Principle block diagram of open and close coil interface

2)Current monitoring of energy storage motor

Its monitoring principle is similar to the current of the open and closed coil. The interface principle block diagram of the energy storage motor is shown in Fig6.

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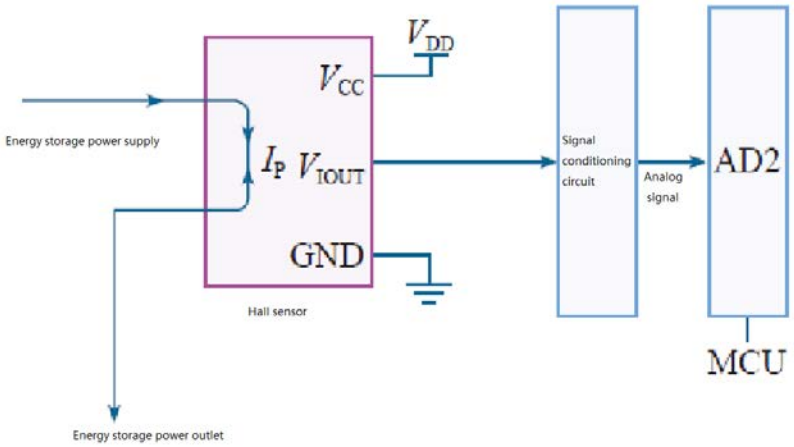

Fig. 6 Energy storage motor interface principle block diagram

3) Temperature and humidity monitoring

To master the operating environment of the equipment, temperature and humidity monitoring of the gas is added in the gas box that switches on the column, and temperature and humidity monitoring is integrated in FTU. It can obtain the temperature and humidity data of the switch on the column and FTU in real-time.

4. First, secondary whole high-reliability research

The primary and secondary connection is through the aviation plug, and the connection state of the cable and the online state of the signal line are the guarantee of the safe operation of the switch on the column. This design USES the universal military aviation plug operation connection interface with high protection grade and good reliability. This design USES the universal military aviation plug operation connection interface with high protection level and good reliability and carries on the standardized definition to its interface. No matter it is the first or second failure, the maintenance-free way of replacement repair is directly adopted to reduce the time of maintenance.

4.1 Primary and secondary connection design

To meet the requirements of various sensor information on the switch on the column and consider the extension of the later collection information, the switch body is configured with a 37-core aviation socket, the feeder terminal is configured with a 26-core aviation socket, a 6-core anti-open aviation socket, and a 6-core aviation socket, as shown in Fig7. Among them, the 26-core aviation socket is used for transmitting energy storage and load switching state signals and zero-sequence voltage signals, the 6-core anti-open aviation socket is used for transmitting phase current and zero-sequence current signals, and the 6-core aviation socket is used for transmitting power supply and line voltage signals of the voltage transformer.

The air plug is sintered with air sealed glass. The raw material has the characteristics of poor temperature resistance, anti-radiation, anti-corrosion, and anti-aging, and has the protection grade of IP67, which can effectively improve the reliability of the primary and secondary electrical connection.

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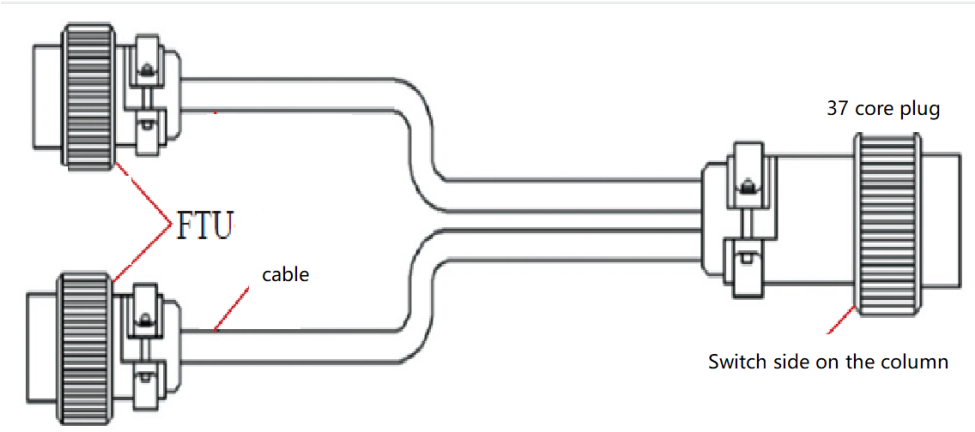

Fig. 7 Schematic diagram of connecting cable between switch and FTU on the column

4.2 Design of on-line condition monitoring of primary and secondary signal lines

By monitoring the online status of each circuit of primary and secondary signal lines, timely send warning messages to the virtual connection, looseness, and breakage of the signal circuit. In this way, the reliability of switch operation on the column can be effectively improved to prevent the failure of primary and secondary connections at critical moments. The on-line condition monitoring design of primary and secondary signal lines mainly includes the following three categories.

1) Sensor signal status monitoring: TV and TA monitor the connection status through disconnection alarm, and the sensor monitors the electrical connection status in real-time through signal collection.

2) Active class signal status monitoring: The wiring circuit has the wiring status monitoring of the active current and voltage signals, such as the connection status of the control circuit and the electrical wiring status monitoring of the active sensors.

3) Other signal status monitoring: By monitoring the normally open and normally closed contacts on the switch on the column, the connection status of the connecting line is monitored in real-time.

The schematic diagram of control loop state monitoring is shown in Fig 8.

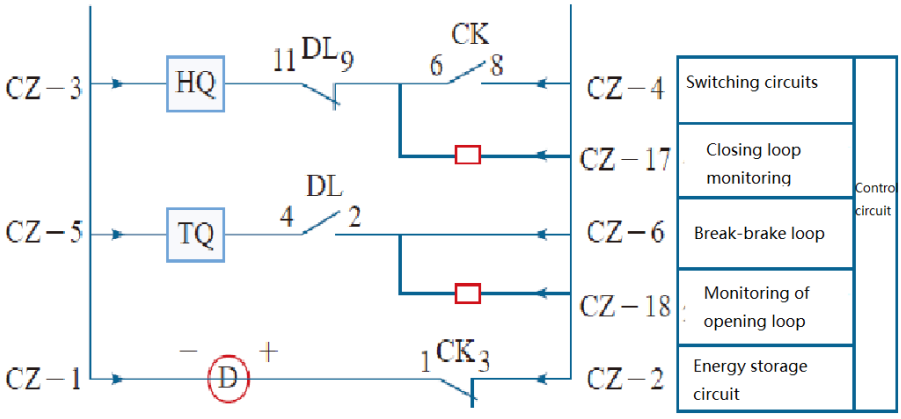

Fig. 8 Control loop state monitoring schematic diagram

5. Conclusion

In this paper, the high reliability of primary and secondary integrated intelligent switch on the column is studied. The design of the first part of the focus on improving the traditional switch on the column and operating mechanism design, effectively solve the condensation water, sealing and mechanism stuck and other aspects of the problem. This design realizes the omni-directional state monitoring of the switch on the column by integrating the function design of FTU with the second part and using modern sensing technology. The first and second integral parts unify the connection interface and

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improve the integration level of the switch on the column. The implementation of this project will effectively promote the integration process of primary and secondary equipment in the distribution network and improve the power quality and power supply reliability.

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