Design of Grinding Tool for Isolating Switch with Multiple Operating Conditions in Substation

Yongsheng Li¹, Xu Dong²*, Zhao Liu¹, Xianfei Lu¹, Na Su¹, Jian Li²

¹State Grid Jinan Electric Power Company. Jinan, China
²State Grid Intelligence Technology Co., Ltd. Jinan, China
dxengineer@163.com

Abstract. The isolating switch in the open substation is exposed to the outdoor environment for a long time, and it is easy to rust due to the erosion of the natural environment, resulting in contact heating and affecting the quality of power supply. The grinding tool with multi-working conditions consists of grinding section, cleaning section, clamping section, connection section, rotating section and control system. The grinding tool is used for isolation switch in the open-type substation with voltage level of 220kV and below. The operation mode of remote control is adopted to polish and clean the isolating switch under multiple working conditions to achieve the task of derusting.

1. Introduction
The insulator of the open substation is exposed to the outdoor environment, and the switch of the disconnector needs to be closed and opened. In the power supply state, the switch of the disconnector needs to be kept normally closed. Isolation switches are washed by rain and other water in the outdoor environment, and rust is likely to occur at the contact points of the blade switch contacts. In the long-term past, it is easy to cause poor contact of the isolation switch, resulting in contact point heating and serious power failure. In order to prevent the contact of the isolating switch from rusting and maintaining good conductivity, the contacts need to be polished. Shenzhen Power Supply Company designed a live grinding device for the contacts of the isolating switch of the substation, which adopts the hydraulic drive mode and uses the rotation of the grinding wheel based on the flexible shaft transmission to perform the grinding operation [1]. The Northwest Electric Power Research Institute and other institutions have developed a GZM high-voltage isolating switch contact live polishing machine, which also uses a polishing wheel to perform live polishing operations on the contacts [2]. At present, most of the contact grinding tools are single-mode using a cleaning cloth or polishing wheel, and the working tools cannot be replaced in real time for the rusted isolation switch contacts, which leads to the inability to achieve complete grinding operations.

In order to effectively grind the contact of the isolating switch with serious corrosion, a multi-degree-of-freedom grinding tool combination operating system was designed, and a multi-degree-of-freedom contact grinding model under unstructured environment was constructed to complete the multiplexing of the isolation knife contacts in the substation. The design of the grinding tool can achieve the grinding and cleaning of the contacts of the severely rusted isolation switch, and solve the problem of incomplete rusting and grinding of the contacts of the isolating switch in the substation.
2. Design
The multi-working condition grinding tool for the isolating switch of the substation adopts a modular design, which is mainly composed of a grinding part, a connecting part, a clamping part, a rotating part and a cleaning part. As shown in Figure 1. The outside of the grinding part is a barbed grinding bar, which is responsible for the main grinding operation of the rusted part, which can grind the rusted part. The connection part mainly serves to connect the clamping part and the working condition rotating part. The rotating part of the working condition can adjust the position of the polishing part and the cleaning part by rotating the turntable to achieve different degrees of cleaning of the rusted parts. The cleaning part is the outside of the cleaning cotton, which can be used for the rusted parts secondary cleanup. The working condition rotating part has 4 working condition positions, which can be expanded according to different cleaning requirements.

![Fig.1 Composition of the grinding tool](image1)

1. Grinding section, 2. Connection section, 3. Clamping section, 4. Rotating section, 5. Cleaning section

2.1. Grinding Section and Cleaning Section
The grinding part is used to grind the contact of the disconnector to be polished, which is mainly composed of the grinding motor, the grinding motor mounting plate and the grinding rod, as shown in Figure 2. The grinding motor mounting plate and the cleaning motor mounting plate are installed on the rotating disk of the working condition rotating part. The grinding motor and the grinding rod are connected to drive through the key. The cleaning part is used to clean or finely grind the contact of the disconnector after the grinding operation of the grinding part. It is mainly composed of the cleaning motor mounting plate, cleaning motor, cleaning cotton, cleaning rotating plate and cleaning rotating fixed plate, as shown in Figure 3. The cleaning cotton (the surface can also be coated with rust remover) is placed on the outside of the cleaning rotating plate through the transition connection. By controlling the rotation of the grinding motor and the cleaning motor, the grinding rod and the cleaning cotton can be rotated, thereby cleaning the rusted parts.

![Fig.2 Composition of the grinding section](image2)

1. The grinding motor, 2. The grinding rod, 3. The grinding motor mounting plate and,
2.2. Clamping Section, Connection Section and Rotating Section

The main components of the clamping part, connecting part and rotating part are shown in Fig. 4.

The clamping part is the connection point of the external equipment, which is mainly composed of a clamping wrench, a left clamping body and a right clamping body. The left clamping body and the right clamping body are respectively installed on both sides of the clamping wrench through bolt connection. The clamping part can be adjusted by 90° according to the actual working direction.

The clamping part and the rotating part are connected by a connecting part, which is mainly composed of a left fixing plate and a right fixing plate. The rotating part is mainly composed of a rotating disk, a rotating motor mounting plate and a rotating electric machine, and the rotating disk can meet the operation requirements of four working conditions.

3. Control System of the Tool

The grinding tool for the isolating switch of the substation is controlled by remote control. The control module is mainly composed of a remote control terminal, an industrial computer, a wireless transceiver, and motor control units (3 motors). The remote control terminal performs data communication with the wireless transceiver device, and the wireless transceiver device performs Wi-Fi communication with the industrial control computer. The industrial control computer sends control commands to the tool to control motors’ start and stop. The control process is shown in Figure 5.
4. Application Scenarios

The grinding tool can be clamped by an insulating rod or a mechanical arm. This article uses the substation live working robot to clamp the tool to work, as shown in Figure 6 and Figure 7. The gripping handle of the grinding tool with the robotic arm performs the grinding operation of the isolating switch. According to the working angle, the angle between the gripping part of the grinding tool and the connecting part is adjusted. The mechanical arm mounted on the robot clamps the grinding tool to the isolating switch, and the rotating disk rotates to move the side of the grinding part close to the disconnector, and starts the grinding motor to perform the grinding operation. The grinding rod is a sharp grinding head, which polishes the rusty surface. After the operation of the polishing part is completed, the rotating motor can be driven to rotate the rotating disk to bring the cleaning part side close to the polishing part for fine polishing and cleaning treatment. In order to enhance the effect of removing rust, the cleaning cotton can be immersed in the rust remover to work, and other working tools such as sanding paper can be installed on the other parts of the rotating disk.
5. Conclusions
The grinding tool for isolating switch with multiple operating conditions in substations can realize the multi-degree-of-freedom operation and the single operation mode is changed. By rotating the grinding tool, the rusty parts can be cleaned in a single direction at a time. At the same time, the secondary cleaning of the rusted part through the cleaning cotton can effectively suppress the cyclic slag circulation and effectively improve the polished quality.

Acknowledgments
This work from the project of Research and Application of Practical Technology of Robots for Live Sweeping and RTV Spraying of Insulators in Open Substations was supported by the Science and Technology Project of State Grid Shandong Electric Power Company in 2019(520601180080).

References
[1] Guoxing Wu, Ronghui Huang. A transformer isolated switch contact charged polishing device[P]:China, CN201710021439.6,2018.
[2] Huayu Yu,Qingkai Li,Wencheng Xu. Live application of the Contact sander used for the Isolated knife gate with high voltage[J]. Power System Technology,2012(11):6-8
[3] Guo Hui Ma Jing,Application of charged Wire Repair Method of Double Circuit Tower with High-pressure Line Getting into Strong Electric Field[J]. Journal of Henan Science and Technology, 2015, Vol.567(7):144-146.
[4] Shouyin Lu, Peisun Ma and Hui Qi. Research on high voltage electric power live line working robot[J]. Automation of Electric Power Systems, 2003(17).
[5] Gang Dong,Xu Dong. Design of the Wire Repair Tool for the Maintenance Robot with Charged used in Substation[J], Advances in Engineering Research ,2018,Vol.16:30-33.
[6] Xu Dong, Mengchao Fu. Optimization Design of the Wire Repair Tool for the Maintenance Robot with Charged used in Substation[J], AEMCME 2019 - Computer Programming and Industrial Design,Vol.563(2).
[7] Shungui Liu,Xin Zhang. Optimization Design of the Maintenance Robot with Charged Used in Substation[J], Proceedings-2018 3rd International Conference on Mechanical, Control and Computer Engineering,2018:141-144.