Studies on Overheating Fault of Disconnecting Switch

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Abstract: This paper mainly presents typical solutions to disconnecting switch overheating and mechanical problems of power grid in Extra High Voltage (EHV). In recent years, many faults have happened in the EHV power grid due to overheating and mechanical problems of disconnecting switches in Inner Mongolia. Dust storm weather and the special structure are main reasons which induced disconnecting switch lower operation reliability. For the overheating problems, the solutions include using conducting metal belt, replacing material of knee-arm wheel and modifying the structure of rolling-contact assembly; for the mechanical problems, the solutions include using dust shield, renovating operating mechanism and decreasing mechanically-driven part. Meanwhile suggestions are proposed as well for the design and application of isolator in the power networks of Western Inner Mongolia and the Northwestern China which have similarly peculiar natural environments.

1. Introduction
In recent years, the lower operation reliability for disconnecting switch in EHV power grid in Inner Mongolia is due to dust storm. For the impact of different climate and environment on the normal operation of electrical equipment, there has been a large number of studies and coherent results, such as climates of alpine, high altitude, snow and so on[1-5]. However, the relatively rare concerning is the effect of dust storm environment on equipment reliability. In this paper, based on the basic structure and working principle of electric rolling-contact-type disconnecting switch, we studied the effect of dust storm environment on the reliability of disconnecting switches. Also, some practical solutions were proposed to improve the operation reliability of the disconnecting switch, which is of great significance for power grid construction, operation and maintenance.

2. Overheating fault
There had been totally 25 times of overheating fault disconnecting switches in the past three years at the 500kV-substation of West Inner Mongolia Power Grid. 10 times of those were happened in Wuhai-Substation, where the dust storm is one of the most serious areas. More than 70% of the overheating disconnecting switch is electric rolling-contact-type. The knee-arm position is the mainly overheated parts, such as rolling contact, gear box, knee-arm wheel and composite sleeve (junction position of rod and even plate). Overheating picture is shown as ‘figure 1’ and ‘figure 2’.
3. Fault cause analysis

3.1. Analysis of overheating failure

Overheating faults are the main factors that caused the lower reliability of disconnecting switches in dust storm climate. The overheating parts of the rolling-contact disconnecting switch is mainly on the knee-arm position, such as rolling contact, gear box, the knee-arm wheel and composite sleeve (rod and even the plate junction). For the structure and working principle of disconnecting switch, it is indicated in ‘figure 3’ and ‘figure 4’. Overheating spots of the disconnecting switch are not only located on the normally conductive channel, such as gear box and rolling contact, but also located on the non-conductive channel, such as disconnecting switch knee-arm wheel and composite sleeve, overheating of knee-arm wheel was shown as ‘figure 5(a)’. For the overheating rolling contact of the disconnecting switch, we found that some rollers are burned severely and the dust deposition is great, as shown in ‘figure 5(b)’. Thus, the severe dust storm climate is the main reason for heat disconnecting switch.
1 ice break hook; 2 rolling contact; 3 rotated shaft; 4 elastane cylindrical; 5 fulcrum; 6 gear; 7 gear box; 8 connection fork; 9 screw rod 10 screw

Figure 4. Electric rolling-contact-type assembly.

Figure 3. Knuckle assembly.

(a) Roller overheating and burning (b) Overheating and burning of crank arm roller

Figure 5. Burning position of overheating disconnecting switch.

3.2. Analysis of mechanical fault
The mechanical jam is another important factor that caused the lower reliability of disconnecting switch in dust storm climate. A majority of fault disconnecting switches were CJ7 type operating mechanism. Its mechanical principle is as follows: the motor start-up firstly, and output shaft is obtained by operating torque through the deceleration of gears, screw and screw nut. Next, the double four-bar mounted on the top of institutions boxes drive the rotating porcelain of middle Phase, then both sides of the adjustment rod are driven by a pair of bevel gears installed on wiring bed, and the lower conductive rod starts to move. The upper conducting tube rotates 180° with respect to the lower conducting tube through the joint between the gear and rack. When near closing and starting gate time, the small roller at the connection fork starts to move on the incline plate of the gear box, and the reset spring and clamp spring and other components of the upper conductive rod start to moving. The dynamic touch-piece is closed or separate so that the main switch is controlled to close or separate.

The operation structure above contains several mechanical steps. However, sandstorms and poor sealed condition of operating mechanism are lead to entering of tiny grains of sand. When the sand caulk is in mechanical transmission parts such as gear, rack, etc., mechanical output efficiency will be affected, which lead to mechanical jam, division improperly and the other failures.

4. Treatment methods

4.1. Overheating fault treatment
Faults caused by overheating which decrease the reliability, the reason of which is due to that the structural design of disconnecting switch cannot adapt to special sand climate and environment. At the basis of those reasons and the structure principle of disconnecting switch, some transform programs are put forward as follows:

Aimed at the overheating causes of disconnecting switch, the transform method included: replacing the roller material of rolling contact assembly, improving roller coating process, increasing the through-flow capacity of roller. Meanwhile, adding enough dust cover to prevent dust entering the rolling contact of the disconnecting switch. The characteristics of those transform methods not only is able to reserve the merits that the upper and lower disconnecting switch conductive tube rotate convenient, but also has the simple and nice-looking structure and convenient maintenance procedure. Moreover, the overheating problem of disconnecting switch is controlled to the certain extent. However, the method involves replacing the roller material of rolling contact assembly and improving roller coating process, which
required that manufacturers of disconnecting switch have to upgrade the current products and completely replace rolling contact assembly upgraded. The structure transformation cycle will be extended and more difficult for those having been operated. Thus, the method is suitable to transform those disconnecting switch still not in practice. The other method is to install the soft conductive connection between the upper and lower conductive tube junction. The current can be conducted mainly by soft conductive connection in lieu of the knee-arm.

The rolling contact of disconnecting switch improved has function of rotation and supplementary diversion. As shown in ‘figure 6’, the soft conductive connection with one end fixed on the reliable cross connected to the upper conductive tube and the other end fixed on the gear box sleeve connected reliable to the lower conductive tube. The application of soft conductive connection is very good solution to the overheating incidents of rolling contact assembly. Also, the soft conductive connection is so easy to produce and install that it is able to accelerate the process of transformation. However, the frequent close and open of disconnecting switch may lead to the soft conductive connection cutting off. Regular observations are necessary. Therefore, it is not easy to maintain. For the disconnecting switch having been putting into operation, it is suitable for applying the above transformation programs.

4.2. Mechanical Fault Treatment

The dust storm environment cause a large number of mechanical faults was mainly due to inadequate consideration on structural design of disconnecting switch that under the special operating environment. There are more mechanical parts that can easily lead to overheating. On the basis of structural principle of the disconnecting switch, we can replace CJ7-type operating mechanism to CJ7A-type. the double four-bar drive of CJ7 have many mechanical parts and many possible point of failure. Thus, the efficiency and output is affected by dust storm climate. On the contrast, The CJ7A give up the double four-bar, turbines are fit at the output shaft directly. The output shaft is connected with vertical rod device through the transfer angle. When it is close or open, robs drive the turbine, the vertical output shaft rotate, the sub-vertical move. In this structure, the middle linked parts decreases, and output torque increases, the volume is also relatively small. Therefore, the operation is easy and flexible. Moreover, the disc spring is installed at both ends of retard box is improving, which controlled the impact to the minimum. Meanwhile, sealing performance required fully consideration against sandy environment in order to increase the anti-wind ability of mechanical body.

5. Conclusion

Using the aforementioned programs, all disconnecting switches of Mengxi 500kV power grid are
gradually transformed. After transformation, the equipment temperature has maintained the normal level, and machinery jam is controlled fundamentally. These have greatly improved the operation reliability of disconnecting switch. The Electrical equipment manufacturers should take care of the geographical characteristics in order to make the design more applicable to the specific local environmental characteristics. As a result, it will not only significantly reduce the cost of manufacturers’ inputs after-sales service, but also is paramount to the safe and reliable operation of the power grid.

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