INFLUENCE FACTORS ON TRANSFER CURRENT EXPERIMENTAL RESULTS FOR FUSE COMBINATION SWITCH

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Abstract: The simplest RMU normally consists of two LBS and one fuse combination switch built in one unit, which is suitable for application in ring distribution network. And fuse combination switch made up of load break switch and power fuse to cut off fault current for transformer protection. In our company, we developed a kind of load break switch of gas insulation. Transfer current switching capability is very important for this kind of switch. For the sake of achieving excellent performance, lots of experiments are taken on transfer current switching test. And we found that there are some influence factors like characteristics of mechanism, arc extinguish method and TRV that affect the experimental results. By considering these kinds of influences, optimize design of fuse combination switch turns into possibility.

1 INTRODUCTION

Electricity is generated from power station and transmitted to consumers through an electrical network. It is essential to be able to cut off the current at any point of the network in order to operate or maintain the network or to protect it when a fault occurs. The ability to break current in an electrical circuit is essential in order to guarantee the safety of people and property in the case of faults, as well as to control the distribution and use of electrical energy.

On normal situation without fault occurs, load current is the actual current on the power system, which is smaller than the rated current. And the rated current is the rms value of current that equipment must be capable of withstanding indefinitely under recommend conditions of use and operation.

Load Break Switch (LBS) is a mechanical connection device, which capable of establishing, sustaining and breaking currents under normal circuit conditions eventually including overload currents in service. And intended to control circuits (opening and closing), it is often intended to perform the insulating function. In public and private MV distribution networks it is frequently associated with fuses for cutting off fault current to protect transformer.

Under normal operation, in MV, circuit breaking occurs with a load current from a few to a few hundred amperes, a low value relative to the short-circuit current (from 10 to 50 kA) and with a power factor greater than or equal to 0.8. The phase shift between the electrical circuit voltage and the current is small and the minimum voltage occurs around the current's minimum. [1]

Under a three-phase fault for a fuse combination switch, the fastest fuse to melt clears the first pole and its striker starts to trip the switch. The other two poles then see a reduced current (87 %) which will be interrupted by either the switch or the remaining fuses. The transfer point is when the switch opens and the fuse elements melt simultaneously. The breaking duty is transferred from fuses to the load break switch. The current is called transfer current with a power factor around 0.2. [2]

In LSIS RMU series, two LBS and one fuse combination switch unit is widely used in Korea distribution system. And the transfer current interrupt capabilities need to upgrade to fulfil the market requirement. For the sake of achieving excellent performance, lots of experiments are taken on transfer current switching test. And we found that there are some influence factors like characteristics of mechanism, arc extinguish method and TRV that affect the experimental results. By considering these kinds of influences, optimize design of fuse combination switch turns into possibility. [3-5]

2 GENERAL INSTRUCTIONS

The voltage range considered is that of Medium Voltage (1 kV - 52 kV), since it is in this voltage range that the greatest number of breaking techniques exist.

2.1 Rotary arc breaking

LBS don't like circuit breaker (CB) to cut off short current. It only need to break and close load current. And there are lots of technologies in MV distribution system for load current breaking in SF6 gas environment. For example, expansion and compression gas to extinguish arc or rotary arc

breaking. In our research activities, we mainly did the research on the rotary arc method.

In this technology, the arc cools through its own movement through the SF6. The high speed rotary movement of the arc is caused by the magnetic field created either by the fault current itself flows or by the permanent magnet. And Schneider is the pioneer on this field. Their SM6 series LBS use permanent magnet to blow arc. For understanding this theory, we studied the patent of rotary arc switch shown on Figure 1.

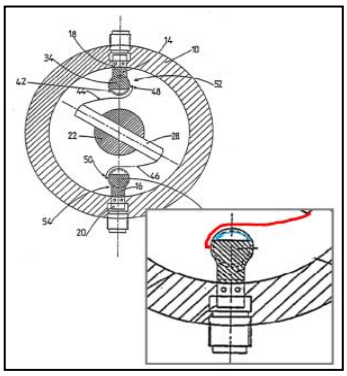

Figure 1: Principle of arcing extinguish by using permanent magnet on stationary contacts.

The invention is applicable to a gas-insulated medium voltage switch. A rotary switch with a sealed enclosure showed on Figure 1, where a rotating contact meets with two stationary contacts supported by the internal periphery of the enclosure. A permanent magnet is incorporated in the stationary contacts to magnetically blow the arc roots on a curved migration track towards hidden locations which are not facing the rotating contact. [6]

2.2 Arc root moving track simulation

For understanding the arc root moving track, we also set up 3D model and made simulation as shown in Figure 2. When the main contacts open, the arc in the magnetic field starts to be accelerated in a circular movement by Laplace force. The arc is thereby cooled in a uniform manner in the SF6. Because of the quick movement of the arc's roots, hot spots releasing metal vapors are avoided and contact erosion is minimized.

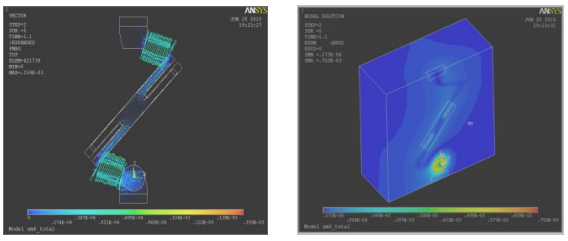

Figure 2: Arc root moving track simulation

2.3 High-speed photographic analysis

When LBS open, close or in continuous CO services, switch is often subjected to several stresses, like dielectrical, thermal, and mechanical. The most important stresses are those which occur during transient operation and breaking, which are accompanied by electrical arcing phenomena.

Arcing behavior is difficult to predict despite current modeling techniques. Experience, know-how and experimentation still play a large part in designing breaking devices.

So we tried high-speed photographic analysis to see the arc moving track in order to optimize the design of LBS. As shown on Figure 3, the LBS model is put into a simplified gas tank with a transparent acrylic back cover. To take account of strength of acrylic cover, SF6 gas pressure is controlled bellow 2psi.

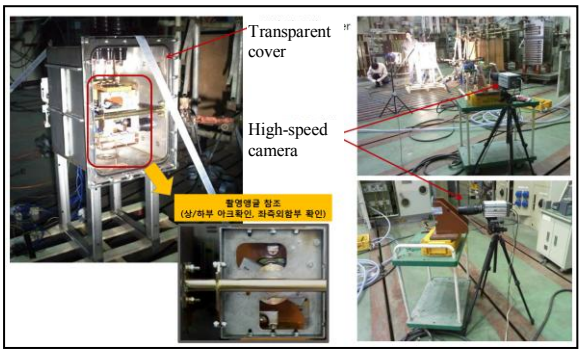

Figure 3: Breaking current test set up for High-speed photographic analysis

From Figure 4, we can see the arc moving track clearly. When switch began to open on picture 1, arc appeared between rotary contact and stationary contact. Because of the force produced by magnetic field on top of stationary contact, arc root quickly moved seen on picture 2. And when the current change to its zero point, arc disappeared showed on picture 3. Owing to arc's movement by magnetic field, the recovery of insulation level between contacts gap raised fast. Re-ignition was stopped, even though current pass the zero point and stats to rise, which can be seen on picture 4.

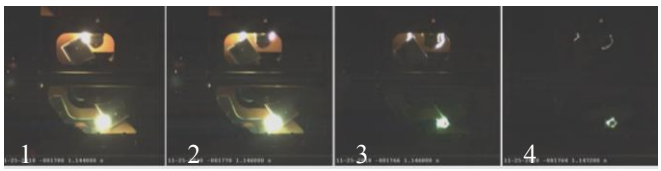

Figure 4: Arc extinguish process by high-speed photography

2.4 Transfer current test

This test duty is performed to prove the correct coordination between the LBS and fuses in the current region where the breaking duty is transferred from the fuses to the switch.

According to IEC standard 62771-105, three break tests shall be made in a three-phase circuit, as shown in Figure 5, with the fuses in two poles replaced by solid links of negligible impedance. And the solid links are the same shape, dimension and mass as those of the fuses they replace. [7]

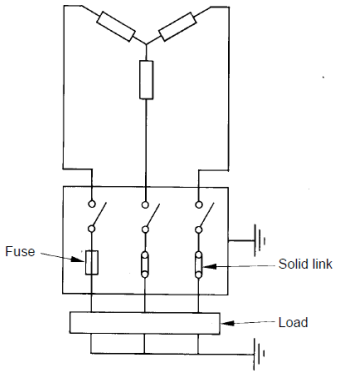

Figure 5: Connection of test circuit

However, in our case, for the actual testing laboratory, the fuses have been omitted and the switch tripped directly. Two phase (R, T) was tested and S phase is disconnected. The rated transfer current is 1000A on 24kV.

2.5 Mechanism characteristic curve

Mechanism characteristic also plays an important role for breaking current. Before current test on LBS, we measured the mechanism firstly by rotary sensor.

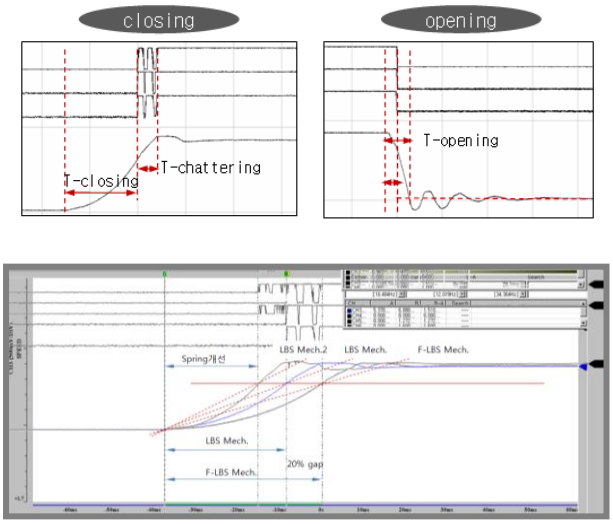

Figure 5: Mechanism characteristic curve

When switch start to open, the rotary contact speed is very important for arc quenching. The more fast speed means the larger gap between contacts, also means the higher insulation recovery in short time. So we increase the close spring and open spring intensity by 20% as shown in Figure 5.

3 CONCLUSION

In this paper, we tried to improve our load break switch breaking capability on transfer current test. We studied the theory of rotary arc breaking method and make simulation on this kind of load break switch. Furthermore, we used high-speed photographic to analyze arc root track on the effect of magnetic field.

At the same time, we also modified the characteristic of mechanism. And found that faster open speed and less rebound on open position will help the breaking capability of load break switch.

In the future, further research will be continued in this field. And we are trying to make rotary arc breaking method meet with puffer method to create a higher ability and stable load break switch.

4 REFERENCES

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[2] IEC62771-105, 2002-08, pp. 63

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[7] IEC62771-105, 2002-08, pp. 49