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Protection Cooperation Between Arrester and Discharge Gap at Neutral Point of 110 kV Grade Insulation Transformer

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Abstract

For the operation mode of the neutral point of the power system in China, there are large current grounding mode and small current grounding mode ; transformers are fully insulated, semi-insulated and graded insulation three ; neutral point protection can be divided into discharge gap separate protection, arrester separate protection and arrester parallel discharge gap protection ; therefore, the types of neutral point protection are diverse, which brings confusion, and the configuration reasons of discharge gap and arrester are not clear. Therefore, this paper will start from the characteristics of discharge gap and arrester, and analyze its application range and mutual cooperation.

Keywords

Arrester, discharge gap, transformer neutral point.

1. 110 kV Transformer Neutral Grounding Mode

The neutral point of power system generally refers to the neutral point of star connected transformer or generator. The operation mode of these neutral points is a very complex problem. From the technical point of view, it is related to power supply reliability, insulation level, relay protection, communication interference and grounding device of power system. From an economic point of view, the neutral grounding mode not only needs to conform to the current situation of the power grid, but also to meet the development plan and comprehensively consider to achieve higher economic benefits.

At present, the grounding mode of neutral point in China can be divided into two categories according to the extinction of short-circuit current arc when single-phase grounding fault occurs : one is the large current grounding mode that requires circuit breakers to block single-phase grounding fault[1] ;the second is the small current grounding mode that the single-phase grounding arc can extinguish itself instantaneously. High current grounding mode mainly includes : 1. Neutral effective grounding ; 2. Full grounding of the neutral point. In the small current grounding mode mainly includes : 1. Neutral point is not grounded ; 2. Neutral grounding through arc suppression coil ; 3. Neutral point grounding directly[2].

At present, the effective grounding mode of transformer neutral point is widely used in 110 kV system in China. The purpose of this is to facilitate the adjustment of the zero-sequence reactance of the system and control the single-phase grounding current level and overvoltage level of the entire power grid. More importantly, the effective grounding mode of transformer neutral point can prevent the breakdown of the neutral point side insulation of the main transformer with graded insulation due to the operation overvoltage and the asynchronous switching, and protect the neutral point insulation[3].

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2. 110kV transformer neutral point protection configuration

The protection configuration of 110 kV transformer is closely related to its neutral point insulation. For the graded insulation transformer, due to its low level of winding neutral point insulation, in order to protect the transformer neutral point insulation from overvoltage breakdown, the arrester with discharge gap parallel protection is generally adopted. The arrester is the main protection, and the gap is the backup protection of the arrester, which not only protects the transformer neutral point insulation, but also plays a role of mutual protection. Taking the main transformer # 1 of a photovoltaic power station as an example, the structural principle of the neutral point gap protection is shown in Fig. 1, and the discharge gap, arrester and grounding isolation switch are arranged in parallel. Under normal operating conditions, the grounding switch is in position, the neutral point is directly grounded to form a zero sequence current path of the power system, the discharge gap is bypassed, and the zero sequence overcurrent I and II sections are configured according to the current transformer at the neutral point of the transformer. At the same time, in order to prevent the transformer neutral point from not grounding operation, parallel arrester as backup ; when the neutral point of the transformer is grounded by a gap, that is, when the neutral point is not grounded, there is no zero-sequence current path between the neutral point of the transformer and the earth. When the system is grounded without losing ground, the zero-sequence voltage or discharge gap current reaches the setting value, and the gap protection action exits the transformer operation. When the transformer is subjected to lightning high voltage, the neutral arrester reliable action protection insulation is not damaged.

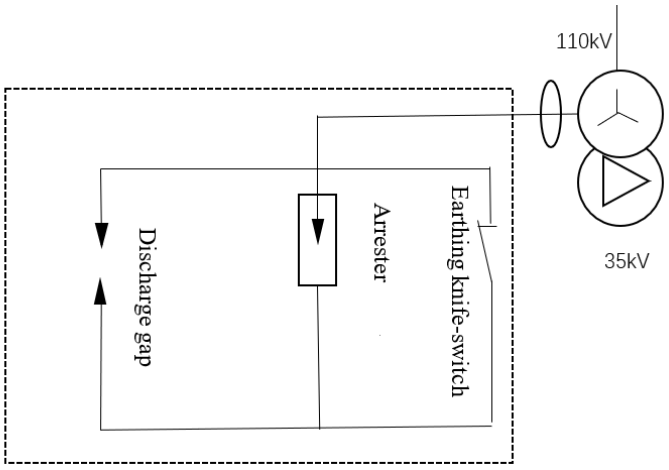

Fig. 1 Structure principle of transformer neutral point gap protection

3. Analysis of coordination between discharge gap and arrester

Discharge gap, also known as protection gap, is generally composed of two metal bars exposed to the air at a certain distance, one of which is connected to the phase line or zero line of the required protection equipment, and the other is connected to the grounding line. The protection gap is broken down under overvoltage and the working bus is grounded to protect the equipment. The advantages of discharge gap protection are simple and reliable, convenient operation and maintenance. Although theoretically it can protect the transformer under lightning overvoltage, operating overvoltage and power frequency overvoltage. But the discharge gap has several main shortcomings, resulting in it can not protect 110kV transformer alone. Firstly, it is difficult to determine the protection parameters of different overvoltage types. The volt-second characteristics of the protection gap are steep (close to the volt-second characteristics of the line insulation), as shown in the figure 2, while the volt-second characteristics of the protected equipment insulation are relatively flat, and the discharge

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dispersion is large. The second is the gap action will produce cut-off, the transformer itself is not conducive to insulation[4] ; third, relying on the action of relay protection to remove the fault, there will be a large and long-term power frequency zero sequence current impact on the main transformer when the system occurs asymmetric grounding short-circuit fault.

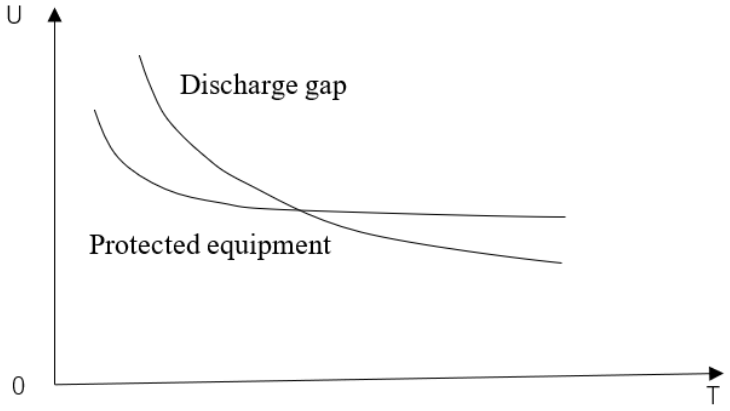

Fig. 2 Coordination between discharge gap and volt-second characteristics of protected equipment

The function of arrester is also to limit overvoltage, but it also has overvoltage protection problems. Therefore, for the overvoltage with short impulse time and limited energy, such as lightning overvoltage and switching overvoltage, arrester discharge can play a role in limiting overvoltage protection equipment. However, for the overvoltage with long action time and infinite energy of supplementary power supply, such as transient overvoltage (including power frequency overvoltage and resonant overvoltage), power frequency power supply can automatically supplement voltage energy, and even the amplitude of arrester discharge overvoltage does not decay or decay is not obvious. Due to the limitation of current capacity, the arrester is easy to reach the heat limit under the action of overvoltage for a long time, so it cannot effectively cope with transient overvoltage. Therefore, it is necessary to combine the discharge gap with the arrester to limit the transient overvoltage.

Thus, the protection of the neutral point is :

1. When the neutral point is grounded directly : the zero sequence current acts as a protection, and the arrester acts as a backup protection to prevent the neutral point from being grounded.

2. When the neutral point is not grounded, the arrester operates under lightning overvoltage and operating overvoltage ; discharge gap action under power frequency overvoltage ;

3. When the power frequency overvoltage and high frequency overvoltage occur simultaneously, the arrester first moves, and then the gap moves to ensure the normal operation of the arrester, so that the arrester will not be damaged.

At the same time, it is necessary to point out that the transformer neutral point protection is jointly completed by high voltage protection and relay protection, and both of them perform their respective functions. The arrester and the discharge gap act against different faults respectively.

4. Conclusion

Therefore, the coordination between arrester and discharge gap is analyzed as follows :

1. The arc extinguishing voltage of the arrester should be higher than the maximum power frequency discharge voltage of the gap.

2. The impulse discharge voltage of the arrester is low, which ensures the action of the arrester under high frequency transient overvoltage, avoids the action of the discharge gap when the

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single-phase grounding fault occurs in the normal system operation, makes the zero-sequence current protection of the gap protection malfunction and expands the power outage range.

3. The maximum power frequency discharge voltage of the gap should be lower than the minimum phase voltage, so as to ensure that the asymmetric fault can be removed.

4. According to GB50064-2014 : 110kV-750kV system neutral point should adopt effective grounding mode, under various conditions the system zero sequence and positive sequence reactance ratio should be positive and not greater than 3[5]. Therefore, when the ratio of zero-sequence reactance to positive-sequence reactance of the system is not greater than 3, the discharge gap should not act ; when the ratio of zero-sequence reactance to positive-sequence reactance of the system is greater than 3, the discharge gap moves.

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