# Development of 110kV Thyristor Assisted Arc Extinguishing Hybrid OLTC

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**Abstract.** On the basis of formulating the technical conditions of 110kV thyristor assisted arc extinguishing hybrid on load tap changer, this paper carries out the mechanical structure design, gives the design scheme of switching switch, selection switch and other connecting parts, and introduces in detail the adaptive improvement design of switching core structure and the coordination of switching process and sequence after adding thyristor module, and then completes the mixing The factory test and the type test of 110kV hybrid OLTC have been completed.

## 1 Introduction

Since the 1970s, many scholars at home and abroad have studied and explored how to improve the tap changing process of on load tap changer by using the non-arc breaking current characteristics of power electronic devices, and put forward a variety of design schemes[1]. However, due to the reliability and manufacturing cost of this kind of switch, it has not been produced in batch and has not been applied in practical application Final approval[2]. In recent years, with the improvement of the production process and technical parameters of thyristor devices, the breakthrough of key technologies such as passive trigger and using telescopic moving contact to ensure the contact action sequence, the hybrid on load tap changer scheme with thyristor assisted arc extinguishing has been substantially developed, which promotes the practical process, and the technology is expected to usher in a period of rapid development.

Based on the technical parameters of the 110kV hybrid OLTC prototype, this paper divides the development of the prototype into mechanical structure design and thyristor module design. The combination of the two is the switching sequence of the switch. This paper focuses on the design scheme of the mechanical structure.

## 2 Technical parameters of 110kV hybrid OLTC

Considering the applicable transformer design requirements, the maximum rated passing current of hybrid OLTC is three-phase 600A, the maximum rated voltage is 2500V, and the rated capacity is 1500kVA. The technical parameters are shown in Table 1.

**Table 1.** Technical parameters of 110kV hybrid OLTC

| | **Model number** | | **JKMIII600Y** | |
|---|---|---|---|---|
| 1 | Maximum rated through current(A) | | 600 | |
| 2 | Rated frequency(Hz) | | 50 | |
| 3 | Phase number and connection mode | | Three phase Y connection | |
| 4 | Maximum stage voltage(V) | | 2500 | |
| 5 | Rated capacity(kVA) | | 1500 | |
| 6 | Short circuit withst and capacity(kA) | Thermal stability (3 sec RMS) | 8 | |
| | | Dynamic stability (peak) | 20 | |
| 7 | Number of working positions | | Standard design: linear adjustment up to 17 levels; positive and negative adjustment, coarse and fine adjustment up to 35 levels | |
| 8 | Switch insulation level | Maximum voltage of equipment (kV) | 72.5 | 126 |
| | | Power frequency withstand voltage (kV) (1min) | 140 | 230 |

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| | | | | | | |
|---|---|---|---|---|---|---|
| | | 1.2/50μsImpulse voltage (kV) | 350 | | 550 | |
| 9 | Internal insulation level /kV (Impact/power frequency) | Insulation class of selector | B | C | D | DE |
| | | Max and min tap | 265/60 | 350/85 | 490/105 | 550/120 |
| | | Any tap phase | 265/60 | 350/85 | 490/146 | 550/160 |
| | | Selector interstage | 150/30 | | | |
| | | Switching switch interstage | Protection of interstage overvoltage with spark gap：90/20 | | | |
| 10 | Mechanical life | | No less than 1 million times | | | |
| 11 | Electrical life | | No less than 1 million times | | | |
| 12 | Switch oil chamber | Working pressure | 0.03MPa | | | |
| | | Sealing performance | No leakage in vacuum under 60 kPa 24h and 133Pa | | | |
| | | Overpressure protection | 300±20%kpa overpressure blasting | | | |
| | | Gas relay | Setting oil speed 1.0m/s±10% | | | |

The insulation design of tap changer is mainly based on the power frequency and the impulse withstand voltage. The insulation of the electrified body and the grounding part is determined by the power frequency for 1min and the impulse voltage. The internal insulation is longitudinal insulation, which refers to the insulation between the charged bodies of the same tap changer, which is determined by the impulse voltage test value. The internal insulation level of JKM series on load tap changer is shown in Table 2. Tap selector with corresponding insulation level can be selected according to rated voltage, regulating range, voltage regulating position and mode of transformer.

**Table 2.** Internal insulation level of JKM series on load tap changer

| **Insulation distance code** | | **a** | **b** | **c1** | **c2** | **d** |
|---|---|---|---|---|---|---|
| Class B tap selector | Lightning impulse 1.2/50μs | 265 | 265 | 485 | 495 | 265 |
| | Power frequency withstand voltage 50Hz 1min (kV) | 50 | 50 | 143 | 150 | 50 |
| Class C tap selector | Lightning impulse 1.2/50μs | 350 | 350 | 545 | 550 | 350 |
| | Power frequency withstand voltage 50Hz 1min (kV) | 85 | 85 | 178 | 182 | 85 |
| Class D tap selector | Lightning impulse 1.2/50μs | 490 | 490 | 590 | 590 | 490 |
| | Power frequency withstand voltage 50Hz 1min (kV) | 105 | 146 | 208 | 225 | 105 |
| Class DE tap selector | Lightning impulse 1.2/50μs | 550 | 550 | 660 | 660 | 550 |
| | Power frequency withstand voltage 50Hz 1min (kV) | 120 | 160 | 230 | 250 | 120 |

## 3 Mechanical structure design of hybrid OLTC

### 3.1 Design scheme of switching switch

The switching core of hybrid OLTC is trial produced. According to the switching principle of hybrid on load tap changer and the existing km type tap changer principle, the auxiliary circuit of thyristor is connected to the basic circuit, and the defect that the single resistance transition circuit can not be used to adjust the load flow is overcome, and the other parts of KM type switch can be fully used to redesign the KM type switching core from the original parallel double fracture circuit The circuit is changed into a series double break circuit, and the mechanical fracture is doubled. The wiring and accessories are adjusted accordingly to meet the switching sequence requirements. The thyristor is added in the switching core. The height of the oil chamber changes with the change of the height of the switching core. The design is based on the volume and layout of the thyristor. The tap selector can be directly used as a whole by using the original km type switch, except that the wire part matching with the oil chamber needs to be changed according to the length of the oil chamber.

The principle of switch core is shown in Figure 1. This scheme adopts three groups of basic thyristor circuits, which overcomes the defect that single resistance transition circuit can not be used to adjust load flow, and can make full use of other parts of KM type switch.

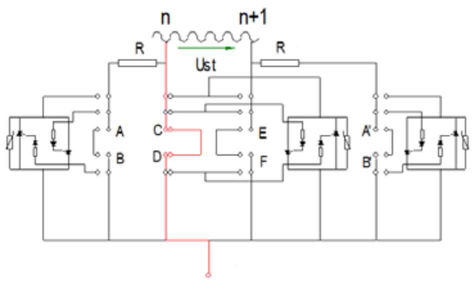

**Fig. 1.** Schematic diagram of hybrid OLTC switch

Switching process: CD-EF switching process, AB on, CD off, A’B’ on, AB off, EF on, A’B’ breaking, CD-EF switching completed. In the process of EF-CD switching, A’B’ is connected, EF is off, AB is on, A’B’ is off, CD is on, AB is off, EF-CD switching completed.

### 3.2 Adaptability improvement of switching core structure

According to the schematic diagram and combining with the existing KM switch mechanism, the KM type switch core is redesigned[3]. The original parallel double fracture circuit is changed to the series double fracture circuit, and the wiring and accessories should be adjusted accordingly.

**Fig. 2.** Mechanical fracture angle layout of KM type switch

The difficulty of this switch design is that the fracture mode of KM type switch is completely different from that of the original km type switch, and the mechanical fracture is doubled (originally 4 pairs of 8 pieces, now 8 pairs of 16 pieces) [4]. The fracture distribution is arranged according to the angle of 120 degrees of each item of three-phase 360 degrees and meets the requirements of switching sequence, which will be very complex and the reliability can not be guaranteed (Figure 2). In order to solve the distribution of mechanical fracture, the scheme adopted after discussion is to expand elastic contact to solve the arrangement problem of four additional pairs of fractures[5], that is, each guide groove in Figure 2 includes 2 pairs of 4 fractures, as shown in Figure 3.

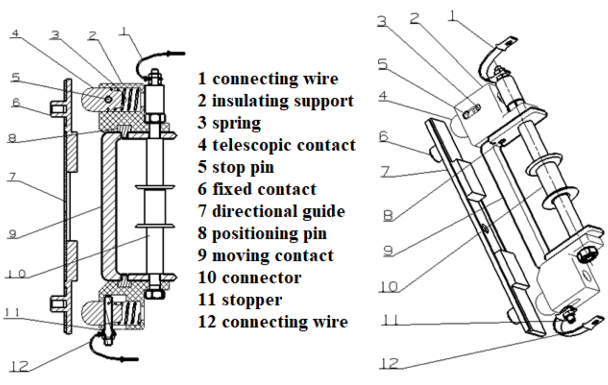


**Fig. 3.** Telescopic contact structure

From the switching process, each main switching circuit (mechanical fracture) has the sequence and real-time sequence requirements in the switching process of different directions. In addition, the triggering mechanical contact of the auxiliary circuit of the thyristor and the mechanical contact of the main circuit of the thyristor are also in sequence in the switching process, that is, the sequence of 8 pairs of mechanical fractures in each phase is fixed. To solve the timing problem, the mechanical fracture sequence of four pairs of main switching circuits is realized by the angle difference of four guide slots, K1 = CD circuit, K2 = AB circuit, K3 = A’B’ circuit, K4 = EF circuit.

Due to the change of the switching principle of the switching core, the corresponding oil chamber must be changed accordingly. The change of the current flow path makes the position of the lead out terminal change, and the plane layout is changed to the upper and lower layout. And because of the addition of thyristor in the switching core, the change of the height of the switch core makes the height of the oil chamber change. The design is based on the volume and layout of the thyristor.

The main difference between hybrid OLTC and KM type switch is that the overall height is about 130-230mm higher than that of KM type switch, and other installation dimensions remain unchanged. There is sufficient insulation margin for the height direction of the transformer applied with this type of switch. The increase of 130-230mm will not affect the insulation of the transformer box by the switch, so it can realize the overall interchangeability.

### 3.3 Prototype development

Based on formulating the technical conditions of 110kV thyristor assisted arc extinguishing hybrid OLTC, and determining the overall anti electromagnetic interference scheme and structure design scheme of hybrid OLTC, a 110kV hybrid switch prototype is developed. The prototype has been tested for contact temperature rise, switching test (including working load switching test and breaking capacity test), short circuit current test and transition resistance test There are 6 tests including resistance test, mechanical test and insulation test. Among them, the working load switching test is switched 50000 times under the test conditions of 2500V and 600A. It is the only hybrid on load tap changer which has passed type test according to the current tap changer standard.

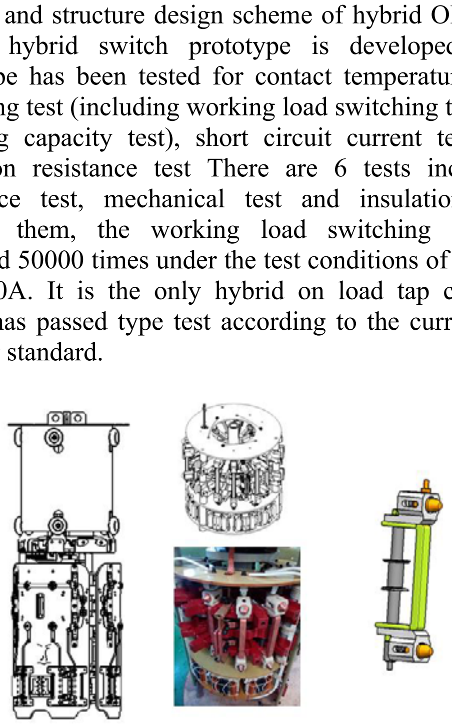

**Fig. 4.** Switch core and telescopic contact structure of 110kV hybrid OLTC

**Fig. 5.** 110kV hybrid OLTC switch prototype

## 4 Conclusion

The technical parameters of 110kV thyristor assisted arc extinguishing hybrid on load tap changer are formulated, including rated parameters and internal insulation level. The structure design scheme of 110kV thyristor assisted arc extinguishing hybrid OLTC prototype is given, including the design scheme of switching switch, selection switch and other connecting parts. The adaptive improvement design of switching core structure after adding thyristor module and the coordination of switching process and sequence are introduced in detail.

The main difference between hybrid OLTC and traditional oil immersed on load tap changer is that the overall height is about 130-230mm higher than that of traditional oil immersed OLTC, and other installation dimensions remain unchanged. There is sufficient insulation margin for the height direction of the transformer applied with this type of switch. The increase of 130-230mm will not affect the insulation of transformer box caused by the switch, so it can realize overall interchangeability.

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