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An Analytical Study on Vacuum and Air Circuit Breakers

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ABSTRACT

This paper gives a clear and comprehensive idea on some switchgear equipment, especially Vacuum Circuit Breaker (VCB) and Air Circuit Breaker (ACB). Most of the figures used here are drawn investigating the real life constructions of Vacuum and Air Circuit Breakers.

Keywords: *Switchgear, VCB, ACB, CT, PT.*

1. INTRODUCTION

The apparatus used for switching, controlling and protecting the electrical circuits and equipment are known as switchgear. In an electric power system, switchgear is the combinations of electrical disconnect switches, fuses or circuit breakers used to control, protect and isolate electrical equipment. Switchgear is used both to de-energize equipment to allow work to be done and to clear faults downstream. This type of equipment is important because it is directly linked to the reliability of the electricity supply.

2. VACUUM CIRCUIT BREAKER

The A circuit breaker is equipment which can open or close a circuit under some conditions like no load, full load and fault conditions. Unlike a fuse, which operates once and then must be replaced, a circuit breaker can be reset (either manually or automatically) to resume normal operation. For the latter operation, a relay circuit is used with a circuit breaker. Vacuum Circuit Breaker (VCB) is such where the arc extinction medium is vacuum. Special characteristics of VCBs are:

a) Very low arcing time
b) Quick recovery of dielectric strength
c) Small contact gap
d) Trouble free service
e) Low energy mechanism

3. MAJOR COMPONENTS OF VCB

Following are the major components of a VCB:

1. Interrupter
2. Jaw connector
3. Epoxy link
4. Operating Shaft
5. Close and Trip coil (Spring)
6. AC/DC motor
7. Lever
8. Interlock keys
9. Limit switch
10. Auxiliary switches

4. OPERATION OF VCB

The breaker can be operated both manually and automatically. While maintenance they have to control it manually as it is not possible to connect it to the switchgear each time to test. That's why they need two switches for manual control; one is 'push to close' and another one is 'push to trip' shown in Fig. 1.

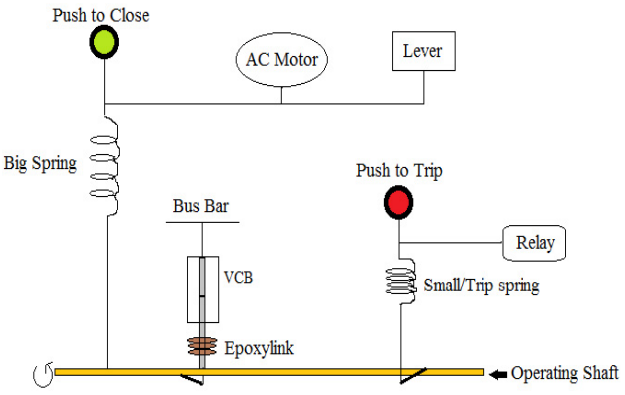

FIG 1. Sketch of the inside view of an indoor VCB.

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Green button is connected with a very strong connecting spring (bigger in size) which is charged/ compressed by taking the energy from AC/DC motor. If we press it then the spring is released from its compression mode which allows a shaft to rotate which is also connected to an Epoxy link just under the interrupter and also making the trip coil (smaller in size compared to the other one) compressed. Interrupter is actually the vacuum chamber with two metal contactors.

When the shaft rotates then the Epoxy link is pushed up to make the metals of the breaker connected which is the normal mode. When any fault occurs then the relay circuit gives command to the trip coil which can be done manually by pressing the red button. If we press it then the trip coil is released from its compressed mode which rotates the shaft otherwise to move the Epoxy link downward to trip the contacts of the breaker. As the trip spring is smaller than the connecting spring, therefore the net force of it fails to compress the closing spring. So the connecting coil can't be charged again. It can only be charged using the AC/DC motor. If the motor does not work properly then the spring can also be charged manually using a lever which is actually a back-up component.

There are some auxiliary switches inside connected like 'X' shape. When any connection is short, then other one is open so that the motor cannot be operated and disconnected at a time. There are two interlock keys there to fix the panel with the desired location and also to open the door of the panel. There are also two limit switches inside to ensure the connectivity of the system. The interrupter is located in between jaw connectors (back side) which are used for connecting the bus-bar. The whole system is manufactured mainly based on mechanical concept rather than electrical.

5. TESTING OF VCB

There are two types of testing that have been done before delivering the product. These are:

1. Routine Test - Endurance test, megger test, high voltage test, analyzer test
2. Type test - Short circuit test

Endurance test: This is done for testing the endurance of coil/ spring of the breaker. While doing this test the breaker remains closed and the whole machinery is connected with the testing panel. It gives the assurance whether the compressed and released mode for the springs are stable or not. This is basically the endurance test.

Megger test: It is done keeping the breaker open. This is basically the insulation test. The breaker is protected by a resin board which works as an insulator.

When the breaker is open then the voltage holds across the open contacts of the VCB. If proper insulation is not given then it can shift to the body of the whole machine. It may be hazardous for the users. That's why it proves to be a very important test.

High voltage test: In this test a very large voltage (2.5 times to the rated voltage) is applied to the breaker to observe whether it can tolerate or not.

Analyzer test: It is done to test the contact timing which means the opening and closing time of the contacts of the breaker.

6. AIR CIRCUIT BREAKER

The Air Circuit Breaker (ACB) is such where the arc extinction medium is air inside the chamber of interrupter.

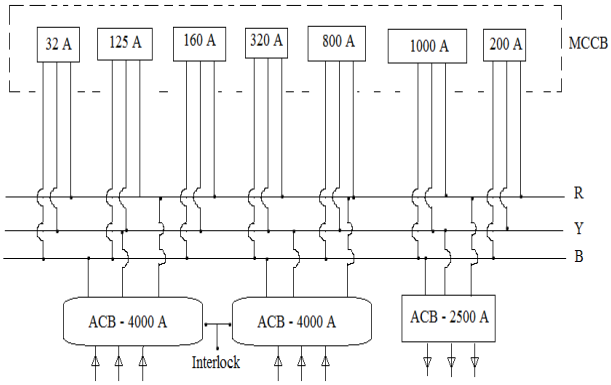

FIG 2. ACB Panel.

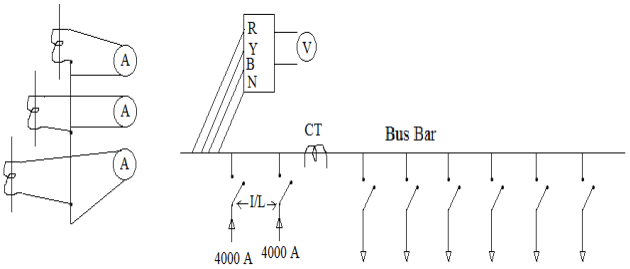

FIG 3. Generalized Diagram of ACB Panel with CT connection.

7. OPERATION OF ACB

From Fig. 2 it can be seen that two ACBs are connected with the bus bars. Each of those can carry maximum of 4000A input current each. These are connected with an interlock key as for when one is on then the other one is off. Some Molded Case Circuit Breakers (MCCBs) are connected with the bus bars which act as outgoing path of the current. It can be seen that these all have different current carrying capability. MCCBs are the circuit breakers which have the rated current up to 2500A with thermal or thermal-magnetic operation. If anyone needs 32A then he will connect the load with the first left MCCB shown in Fig. 2. That's how these all vary with the customer's need. There is an ACB of 2500A as well. If anyone needs 2500A for use then he can directly take it from here as it carries outgoing current.

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In Fig. 3, Current Transformer (CT) and Potential Transformer (PT) connection with the ammeter basically is shown. It is a bit generalized form of Fig. 2. It can be observed that the CTs are connected with the three bus bars. Then 3 ammeters are connected with CTs to show the measured value of the current. That's how the currents of each of the phases can be observed. As the voltage is same for all the phases so there is only 1 voltmeter which is connected with the PT.

The purpose of using it is just same as VCB but the difference lies in the arcing medium of the contact chamber or the interrupter. Here, air is compressed in the interrupter to reduce the arcing while contacts are opened or closed. Some clients prefer it because they can manually take the required amount of current from it using some MCCBs.

Air circuit breakers are most commonly found in large industrial facilities. They are typically controlled electronically. An important characteristic of air circuit breakers is that they are almost always set up to facilitate easy maintenance. There is a drawback of it as well. If the breaker is damaged, it is damaged forever. There is no way to replace it. But for VCB we could easily change the interrupter and then sets a new one in place of it.

8. CONCLUSION

In our country lot of factories have been developed to manufacture circuit breakers and export to abroad as well. They just bought the equipment from China or India and assemble here in our country to produce VCBs and ACBs. I think this paper will present a clear outlook for those who wish to work with such type of production and develop their career in the field of power transmission and distribution.

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