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Retrofit of MOCB with VCB

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***Abstract*: In recent times, the need for increased economy, capacity, quality and productivity to maintain a competitive edge has motivated many industries to modernize aging plants facilities and processes; one result has been a gradual increase in electrical system capacity, placing higher demands on existing electrical control equipment which have some financial impact on any firm. Age old electrical control equipment often does not provide any of the indications of failure – it is a "silent sentinel" and fails on a "go-no-go" basis, sometimes with catastrophic results by switching ON/OFF of electrical equipments mainly age-old motors of degraded insulation. To cope up with the process demands with increased reliability, the age old switchgear equipment mainly Oil circuit breakers requires a retrofit with latest circuit breakers of either Vacuum or SF6 technology. In this paper drawbacks of traditional MOCBs are discussed and s a retrofit solution with VCB is highlighted.**

***Keywords*: Circuit breaker, MOCB, VCB, SF6, Retrofit.**

1. Introduction

Most of the presently well established industrial are started a long back of 20 to 25 years back. The electrical supply from State electricity grids are taken and distributed within the industrial units by stepping down of voltages with transformers and by the control of Circuit breakers. The document starts here. Copy and paste the content in the paragraphs. All these MOCBs worked have almost completed their useful life. In the recent past, these MOCBs are experiencing more problems in breaker mechanism particularly in case of high inertia loads starting direct on line and non – availability of spares (production being stopped by OEM) necessitates to go for a retrofit.

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2. Evolution of MOCB

The experience gained from the usage of dielectric oil in transformer for both insulation and cooling purposes has paid the way for the invention of Bulk Oil Circuit Breaker (BOCB). In BOCB, oil serves a two-fold purpose, i.e., as means of extinguishing the arc and also for providing insulation between the live parts and the metallic tank. This is the oldest amongst the three types having been developed towards close of the nineteenth century. In its simplest form the process of separating the current carrying contacts was carried out under oil with no special control over the resulting arc other than the increase in length caused by the moving contact's. The disadvantages of bulk oil circuit breaker are that it requires large quantity of dielectric oil though a little quantity is required for arc extinction, because of the requirement of enough insulation between the contacts and the earthed tank.

As the system voltages and fault levels increased the Bulk Oil Breakers required huge quantities of insulating oil also pose a fire hazard and became unwieldy in size and weight. This added enormously to the cost of a power system. Simultaneously improvements were made in the technique of ceramics. The function of oil as insulating medium in the Bulk Oil Breakers was transferred to the porcelain containers. Only a small quantity of oil was used to perform its functions as arc quenching medium. This led to the development of minimum oil circuit breakers. Still at all voltages from 33 kV and above the costs of these breakers inclusive of current Transformers compete favorably with oil circuit breakers (OCBs). Of late, Minimum Oil circuit breakers have been developed by many manufacturers at different operating voltages of 3.6KV, 7.2KV, 12KV, 36KV, 72.5KV, 145KV, and 245KV and even up to 420KV.

3. Constructional details of MOCBs

The cross sectional of one pole of MOCB is shown in Fig. 1.

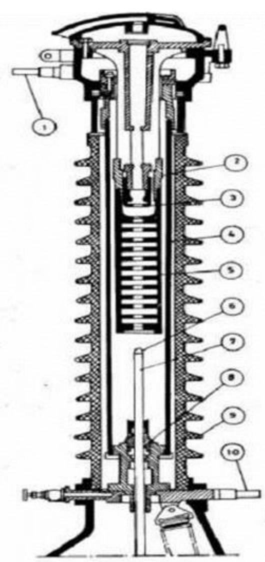

Fig. 1. Cross section of MOCB Pole

The most important part of the breaker is its extinguishing chamber. This takes the form of an insulating cylinder containing oil, in the axis of which moves the contact rod and within which breaking occurs. The arcing chamber is supported at its base by a casing enclosing a mechanism whose function is to move the contact rod. According to the impulses given by the control mechanism. In the on position, the current flows from the Upper current terminal (1) to the contact fingers, (2) Follows the movable contact rod (7) and reaches the current terminal (10) across the lower contact fingers (8). At the beginning of the stroke and before breaking, the contact rod strongly pulled down. Wards by the tripping springs, starts a high speed opening motion. Then, an arc strikes between the contact rod tips (6) and the stationary Arcing ring (3) protecting the upper contact fingers. At this moment gases escape without hindrance towards top of the apparatus. The contact rod rapidly reaches a very high linear speed; it moves the arc downwards and forces it to enter the explosion pot (5) where it is maintained rectilinear and is elongated in a direction opposite to the release of gases towards fresh oil. Since the arc is as short as possible the arc voltage is minimized and the energy dissipated is reduced. Still, since the gases can no longer develop freely, they generate a considerable pressure in the explosion pot (5), thus producing a violent upward axial blast of oil vapor, exhausting the highly ionized gaseous mass. The optimum distance is thus obtained, the jet of oil causes the dielectric strength to be rapidly increased, and at the following current zero, the arc is impeded from restricting and the breaking is thus achieved. The explosion pot (5) is intended to withstand high pressures. It is partitioned into several components by means of discs whose function is to retain a certain quantity of fresh oil while the first break is proceeding; this allows a second break to occur with complete safety at the full short circuit current.

4. Disadvantages of MOCBs

The main draw backs are as follows:

- High maintenance and Fire hazard
- Quality of the oil deteriorates with the number of operation due to thermal decomposition.
- Quick carbonization results in sludge formation.
- Contact oxidation, corrosion which increases the contact resistance, which adds to increased oil decomposition.
- If loss of oil is left unnoticed, during fault conditions the breaker is forced to break the circuit which may result in catastrophic situation.
- Influence of Duty Imposed
- Deterioration of Oil

5. Maintenance aspects of circuit breakers

Maintenance can only commence after the circuit breaker is switched out of service, isolated and earthed, although metal clad circuit breakers of truck type do not require earthing once they are withdrawn from service and discharged. To gain access to MOCBs or to facilitate safe working the interrupting, insulating or operating medium oil may have to be removed.

The following are typical maintenance activities in practice for circuit breakers.

- Inspection, cleaning and lubricating.
- Periodic replacement of parts.
- Mechanism checks.
- Contact resistance measurement.
- Assessment of interrupting and insulating medium
- Contacts checking
- O-Rings and oil seals replacement.

6. Typical failures of the circuit breakers

The circuit breaker exists to disconnect faults on the other parts of the system. Occasionally the fault is associated with the circuit breaker itself. These may be categorized as

1. Breaker does not trip during fault condition open the circuit to interrupt current.
2. Circuit breaker opens and then closes again.
3. Circuit breaker opens and then repeatedly closes and opens.
4. Fault or load current is not interrupted, and the circuit breaker interrupter has a major failure.
5. Circuit is unintentionally interrupted (false tripping) with possible safety and economic damage issues.
6. Breaker does not close the circuit to conduct current.
7. Breaker does not close the circuit to conduct current in one or more poles
8. Circuit is unintentionally closed with possible safety and economic damage issues.
9. Breaker with improper contacts, which may result in thermal damage to contact assemblies.
10. Failure of insulator of MOCB.
11. Contact failure as shown in Fig. 2.

Fig. 1. Contact failure example

A failure of interrupting or insulating medium is usually associated with depletion or contamination of the medium. The typical internal breaker problems noticed during the internal breaker inspection of MOCB includes.

All the above problems coupled with non-availability of spares due to stoppage of production of MCBs by most of the manufacturers necessitated to for a retrofit. These MOCBs also have so many internal components as shown in Fig. 3.

Fig. 3. Internal components of MOCB

7. Retrofit Options

In this section the various alternatives available to continue smooth running of the plant by circuit breakers using vacuum, SF_6 are studied. One of the 3-R options can be considered to help the remedy

- Replace
- Rebuild
- Retrofit

Out of these options, Retrofit will be a suitable option as it makes use of latest state of the art proven technology interrupter, the component or assembly subjected to the most strenuous duty, in addition to direct replacement without much dimensional changes. This is on par with complete equipment replacement, but at a much lower overall cost. Now both the options of retrofitting with SF6 and VCB are discussed.

SF6 CB: In a Sulfur hexafluoride circuit breaker (SF6), the current continues to flow after contact separation through the arc whose plasma consists of ionized SF6 gas. It is shown in Fig. 4.

Fig. 4. SF6 CB

As long as it is burning, the arc is subjected to a constant flow of gas, which extracts heat from it. The arc is extinguished at a current zero, when the heat is extracted by the falling current. The continuing flow of gas finally de-ionizes the contact gap and establishes the dielectric strength required to prevent a re-strike.

VCB: In a Vacuum circuit breaker(VCB), vacuum interrupters are used for breaking and making load and fault currents. When the contacts in vacuum interrupter separate, the current to be interrupted initiates a metal vapor arc discharge and flows through the plasma until the next current zero. It is shown in Fig. 5.

Fig. 5. VCB

The arc is then extinguished and the conductive metal vapor condenses on the metal surfaces within a matter of microseconds. As a result, the dielectric strength in the breaker builds up very rapidly.

8. Comparison of the SF6 and VCBs

The comparison between these two is done op some operational aspects as shown in Table 1.

Table 1
Comparison

Criteria	SF6 Breaker	VCB
Summated current cumulative	10-50 times rated short circuit current	30-100 times rated short circuit current
Breaking current capacity of interrupter	5000-10000 times	10000-20000 times
Mechanical operating life	5000-20000 C (Close)-O operations	10000-30000 C-O operations
No operation before maintenance	5000-20000 C-O(Open) operations	10000-30000 C-O operations
Time interval between servicing Mechanism	5-10 years	5-10 years
Outlay for maintenance	Labor cost High, Material cost Low	Labor cost Low, Material cost High
Reliability	High	High
Dielectric withstand strength of the contact gap	High	Very high

With the detailed comparison of operational aspects and switching operations of VCB and SF6 circuit breaker, VCBs are found to be superior to SF6 circuit breakers up to 33KV as the present day engineering practices and trends.

Advantages of Vacuum Circuit Breakers with respect to MOCBs.

- Less weight of moving parts as the number of parts is one - third of MOCB as well as SF6 circuit breakers.
- No oxidation of contacts since they are in vacuum, which increases the life of the contacts.
- Restrike free as the rate of recovery of dielectric strength is faster in VCB than in any other CBs.

- High speed, safe and clean operation typically less than 3 cycles against 4.5 cycles of MOCB.
- Free from fire hazard and spare parts replacement cost whereas oil and seal rings has to be changed in MOCB once in a year.
- Low driving energy (Fig. 6) for given current. At initial contact separation, the VCB is already in state of breaking at zero current. Vacuum is the ideal dielectric and the breaking time is extremely low. Therefore, there is no need for generating artificial conditions for arc quenching and contact separation is minimal. All this translates to less required stored energy and a less complicated breaking mechanism than any other type of breakers.

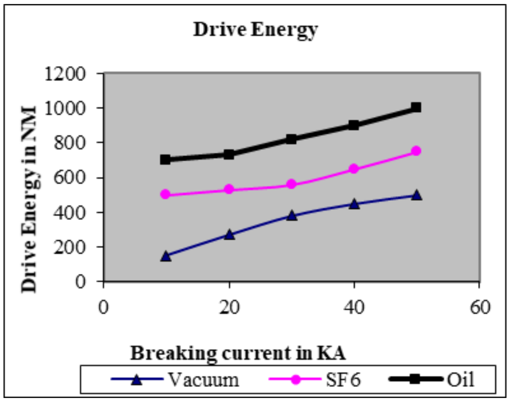

Fig. 6. Drive Energy requirement

- Low arc energy (Fig. 7)

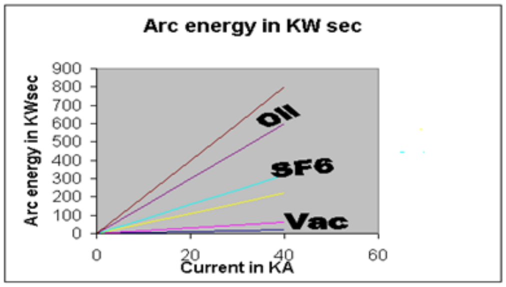

Fig. 7. Arc energy dissipated

- Highest dielectric strength (Fig. 8)

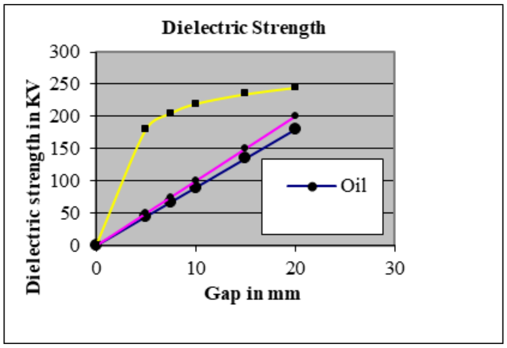

Fig. 8. Dielectric strength

Even though VCB have so many advantages, it is suffering with following significant drawbacks:

1. Monitoring of vacuum loss in VCB is not possible since such provision will provide leakage paths. But manufacturers experience shows the vacuum loss in VCB in its life is negligible.
2. Need of Surge Suppressors which can be met easily.

9. Conclusion

From this detailed study and analysis of maintenance of MOCBs and the non-availability of spare parts produced by Manufacturers and the development of new technologies in HT circuit breaker trends, to extend the life of the electrical equipment to serve the existing production facilities, retrofit with VCB is the best and suited option by providing the necessary need of the hour without much dimensional changes and also with minimum or no shut down time. Taking into consideration the amount needed for the complete retrofit, with the available budget, which can be carried out in phased manner to reap the benefits by any industry.

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