A Review Paper on Hybrid Circuit Breakers

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International Journal of Research in Electrical & Electronics Engineering
Volume 3, Issue 4, October-December, 2015, pp. 08-12
ISSN Online: 2347-5439 Print: 2348-0025, DOA: 15112015

ABSTRACT

To ensure safe and healthy operation of electrical power system network, high voltage circuit breakers are really important so that faulty sections can be effectively isolated from the healthy part of network. Depending on transmission line's power rating vacuum circuit breakers and SF_6 circuit breakers are an effective choice. A need of hybrid model of circuit breakers is analyzed by reviewing the merits and demerits of the two mentioned above.

Keywords: *Vacuum Circuit Breakers, SF_6 Circuit Breakers, Hybrid Model.*

I. INTRODUCTION

The main motive of this paper is to elaborate the ongoing research and development in high voltage field of engineering. The paper aims at highlighting the need of hybrid model of circuit breaker by presenting a deep comparison between SF_6 interrupter and vacuum interrupter. A circuit breaker is designed to detect and isolate any faulty section of the network through the excitation signal received from the relay assembly which is incorporated in the transmission system. It act as an automatic switch, soon as the relay senses the fault it sends a tripping signal to the isolator which initiates the process of interruption of current. As the breaker's movable contacts begin to separate, the contact area between them reduces considerably thereby raising the current density which results in production of an arc.

This arc seriously affects the breaking capacity of the circuit breaker and needs to be extinguished.SF_6 circuit breaker uses the dielectric strength of sulphur hexafluoride to quench the stretched arc where as vacuum circuit breaker both the fixed & moving contacts are enclosed in vacuum. During any fault, the movable contact separates from the fixed contact resulting in minimal arcing. To model a hybrid circuit breaker the advantages of SF_6 and vacuum interrupters are compiled together by connecting them in series.

II. COMPARISION BETWEEN VACUUM AND SF_6 CBS

SF_6 breakers can be used against high voltage levels as the dielectric strength and thermal conductivity of SF_6 gas is higher. Vacuum CBS on the other hand are employed where the voltage levels are medium (5-38KV). Comparatively compact equipments having to occupy less installation space can be manufactured using SF_6. Yet SF_6 is a green house gas contributing to global warming and also it is very toxic at higher temperature. In contrast recyclable materials such as glass container and metallic components are used in construction of vacuum CBS which is environment friendly. They have light weight, compact size & a longer operation life but possess a poor insulation characteristic with longer vacuum gaps. SF_6 CBS are most commonly used as cost of vacuum CBS is higher.

ISSN (O) 2347-5439
(P) 2348-0025

SF_6 CBS requires higher operating energy as energy is required to compress the gas. Whereas operating energy requirements of vacuum CBS is low, since relatively small masses are moved over a very short distance. In vacuum CBS the number of short circuit operating ranges (30-100) while in SF_6 it lies between 10 and 50.

A very small value of transient current of high frequency are interrupted by SF_6 CBS on the other hand extremely rapid deionization in vacuum interrupters results in interruption of currents irrespective of their values. In terms of maintenance, labour cost is high and material cost is low in SF_6 interrupters, while it is vice-versa in vacuum CBS.

III. NEED OF HYBRID CIRCUIT BREAKERS

The main focus of ongoing research in the field of high voltage engineering on such a model of hybrid CBS have potential to take over SF_6 CBS in future. The vacuum interrupters have a faster dielectric recovery as it has ability to recover the dielectric strength across the interrupting gap at the time of current zero. Figure1 shows two comparison of dielectric strength recovery speed between SF_6 interrupter and vacuum interrupter when the gap is 6.35mm breaking current 1600A, 180A vapour pressure. The rate of rise of vacuum recovery voltage is 20 KV\s which is faster than SF_6.
These types of CBS have following shortcomings:-

1. Under continuous voltage stress random dielectric breakdown occurs across the open contact of the CB which can lead to energizing of the system to be isolated. This breakdown occurs for approximate one cycle of system frequency.
2. The butt contacts of the interrupter may bounce or close. The multiple make and break operation in the circuit may lead to the rise in voltage above the insulation level of the system and equipments.
3. As the current reaches zero during current interruption the vacuum interrupter chops this current. Due to this chopping High voltage is generated which are comparable to system voltage but are less than the insulation levels.
4. the higher dielectric and thermal recovery characteristics of SF_6 circuit breakers provides a higher dielectric withstand capabilities to the breaker under a continuous voltage stress this intern prevents random breakdown of the gap by isolating the breaker from the system. The wiping contacts of SF_6 breakers are in the shape of tulip and bayonet. As the arc resistance of SF_6 is higher than vacuum interrupters thus in hybrid model SF_6 bears the main voltage drop and works in conjunction with vacuum breakers to complete the current interruption.

The advantages of the hybrid model over vacuum and SF_6 interrupters are as follows.

1. It has the capability to switch line faults at comparatively higher voltages.
2. As higher operating force is not required hence the size and cost of breaker reduces.
3. Various standard designs are available of hybrid breakers which can be applied to compact substation breakers and free standing breakers.
4. Its capability to deal with steep- rising transient recovery voltage (TRV) is excellent.
5. A basic interrupting module can be formed with a rated voltage of 145kV

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(P) 2348-0025

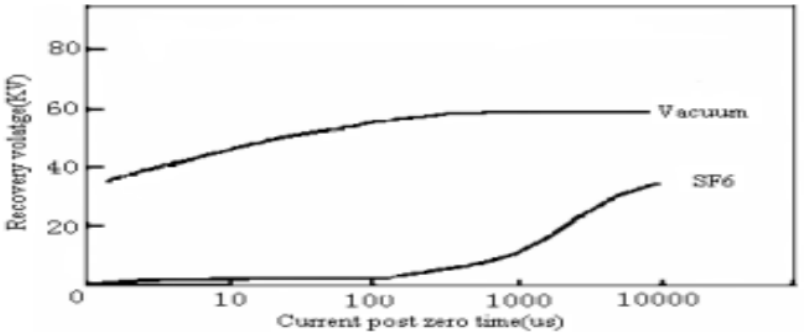

Fig. 1. The Comparison of Dielectric Recovery Speed between SF6 Interrupter and Vacuum Interrupter

IV. CURRENT INTERRUPTION IN HYBRID MODEL.

The minimum arc duration in vacuum CB is shorter when compared to SF_6 CB by several milliseconds. Hence the opening of SF_6 CB is preferred initially followed by the opening of vacuum CB with delay of few milliseconds. Since, two interrupters are connected together therefore current can be interrupted by each of the interrupter.

4.1 Interruption Initially by Vacuum Interruption

In this case, current is first interrupted by the vacuum interrupter. This operation is observed at higher current levels. The initial recovery voltage peak is first transmitted by vacuum CB and the later higher peak value is shared by SF_6 interrupters as shown in figure2.

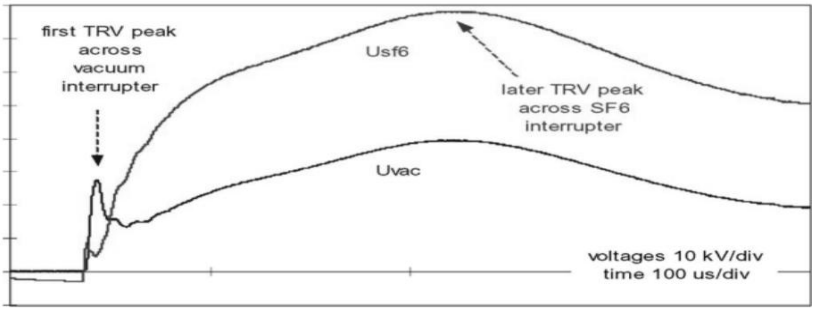

Fig-2 Transient Recovery Voltage of the Two Interrupters

As seen in figure 3, the vacuum arc extinguishes at zero current while the SF_6 arc continues for next 5usec and then after current zero 8A post arc current flows in the vacuum interrupters.

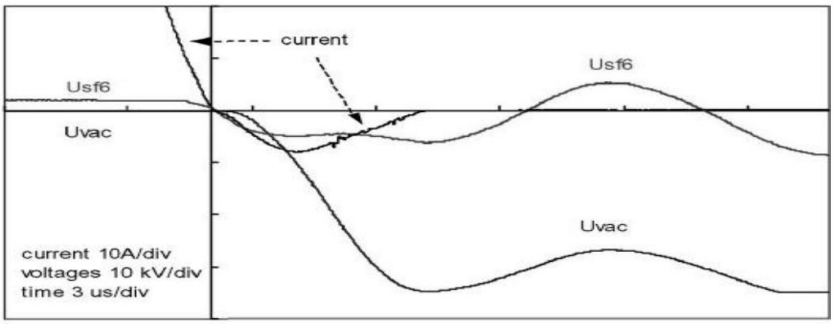

Fig-3 Current Zero Region, Vacuum Interrupts First

When the vacuum post arc current decays to zero then only the SF_6 post arc current is forcibly chopped to zero. Due to this, the arc voltage and current do not cross zero simultaneously and the arc voltage is initially of opposite polarity.

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(P) 2348-0025

4.2 Interruption Simultaneous by Sf_6 and Vacuum Interrupter

In this case, both vacuum and SF_6 interrupters simultaneously interrupt current. Conditions in which current is less than the maximum current, this mode of operation is observed. Here however the performance of SF_6 breaker is reducer significantly but it is sufficient to do the job alone. The post arc current ofSF_6 is much smaller compared to the vacuum CB, so the flow of vacuum arc charge is stopped by SF_6 CB. The post arc vacuum charge remains trapped. This prevents the build up of transient recovery voltage (TRV) in vacuum CB until all the charge disappears. Therefore complete transient recovery voltage is carried by SF_6 interrupter. The above operation can be easily seen in figure4 below. The performance of hybrid breaker in the first mode is better than in the second mode.

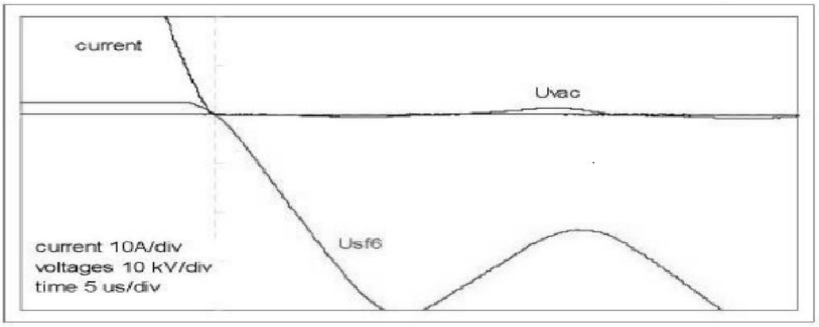

Fig-4 SF_6 and Vacuum Interrupt Simultaneously

V. DESIGN OF HYBRID CIRCUT BREAKER

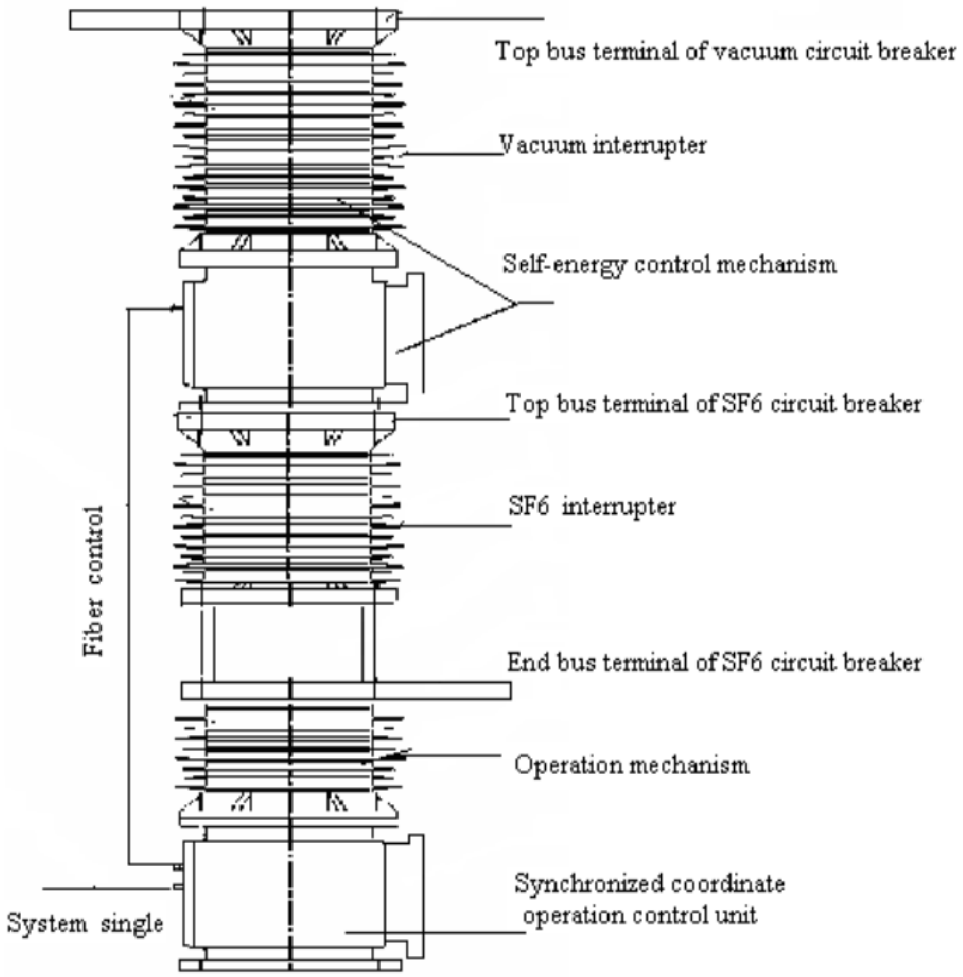

Fig.6. Structural Representation of Hybrid Circuit Breaker

ISSN (O) 2347-5439
(P) 2348-0025

Recent studies on circuit breakers emphasizes on designing a hybrid circuit breaker operation mechanism which have a strong controllability and low dispersion degree. An operating mechanism that connects two interrupters with the help of connecting rods or a spring is adopted by former researchers. This leads to a very weak controllability property and low dispersion degree. A hybrid circuit breaker based on fiber control vacuum interrupter connected in series with SF_6 CB.

This scheme utilizes a synchronized coordinate operation control unit which adjusts the coordination movement of the two interrupters in microseconds. The top bus terminal of vacuum CB is connected to the bus input, and the end bus terminal box is linked with top bus terminal of SF_6 CB. Bus output is connected to the end bus terminal of SF_6 CB, its operating mechanism and synchronized unit are placed at lower potential. The synchronization unit of hybrid CB receives system control and performs synchronized operation to operate the vacuum CB and SF_6 CB respectively.

VI. CONCLUSION

From the testing results it is clearly observed that initial peak of transient recovery voltage drops across the vacuum breaker and the later much higher peak are sent to SF_6 interrupter. Hence both SF_6 and vacuum circuit breakers assist each other. The capability of vacuum circuit breaker to withstand the steep rise of the recovery voltage reduces the pressure of SF_6 gas. Hence it can be concluded that the breaking capacity of hybrid circuit breaker is more than the SF_6 breaker. In the near future, hybrid circuit breakers are more likely to be used as an alternative to SF_6 circuit breaker for high level operations.

REFERENCES

[1] R.P.P. Smeets, V. Kerteszl, D. Dufoumet, D. Penache2, M. Schlaug, “Interaction of a Vacuum Arc with an SF_6 Arc in a Hybrid Circuit Breaker during High-Current Interruption,” XXIInd Int. Symp. on Discharges and Electrical Insulation in VacuumMatsue-200_6.

[2] Liao Minfu, Cheng Xian, Duan Xiongying and Zou jiyan, “Study on Dynamic Arc Model for High Voltage Hybrid Circuit Breaker using Vacuum Interrupter and SF_6 Interrupter in Series,” XXIVth Int. Symp. on Discharges and Electrical Insulation in Vacuum - Braunschweig – 2010.

[3] A. Iturregi, E. Torres, I. Zamora, O. Abarrategui, “High Voltage Circuit Breakers: SF_6 vs Vacuum,” International conference on renewable energies and power quality(ICREPQ’09).

[4] Cheng Xian, Liao Minfu, Duan Xiongying, Zou jiyan, “Study on Breaking Characteristics of High Voltage Hybrid Circuit Breaker,” XXIVth Int. Symp. on Discharges and Electrical Insulation in Vacuum - Braunschweig – 2010.

[5] U S Patent, Patent no. 4087664, Filing date: Aug 29, 1975, Issue date: May 2, 1978.