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Problems Associated with the Sheilding Cylinder for Shunt Reactor Failure

Sanjay kumar[1], Prof. Madhu Upadhyay [2]

[1]M Tech Scholar, DEPARTMENT OF ELECTRICAL ENGINEERING, NRI INSTITUTE OF RESEARCH AND TECHNOLOGY, BHOPAL,INDIA
[2]HOD, DEPARTMENT OF ELECTRICAL ENGINEERING, NRI INSTITUTE OF RESEARCH AND TECHNOLOGY, BHOPAL,INDIA

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Abstract— In case of failure of shunt reactor in long transmission line system, voltage of system shoots up which may lead to forced outages of the system. In this paper ,present here to work on the development of new robust, operator friendly & more reliable earthing lead of shield cylinder that is very important the part of shunt reactor. Grid outage is the state of complete absence of electricity at the consumer's end. There are many causes of power failures in a Grid. One of the causes is the shunt reactor failure at transmission substations. Shunt reactor is an intensive key component of transmission substation for maintaining continuous flow of electricity. It is installed for improving the efficiency of transmission line through reactive power compensation and to offset the capacitive effect of the transmission line and to regulate the voltage and reactive power.

Keywords:* *Shielding Cylinder, Shunt Reactor Failure, Grid Outage, Redsign etc.

1. INTRODUCTION

Shunt reactors in power systems they are an investment for today and for the future. A shunt reactor is commonly used for the compensation of reactive power in long high-voltage transmission lines and in cable systems by controlling the line voltage. It is very critical for the voltage system profile to compensate the reactive power and this is helpful for the power factor improvement, decrease of losses and thus increasing the energy efficiency of the system.

In high and extra voltage, long and medium transmission lines they generate more reactive power due to their shunt capacitance that is proportional to length of the line. It is necessary to transmit power and to support voltage as reactive power at light/low loads have the undesirable effects such as: receiving end terminal voltage rises due to the low of capacitive current through the line inductance, sending end terminal voltage due to low of capacitive current through the impedance source, synchronous machines rises due with self-excitation in the event of load tripping (Sharma, 2013). It is not usual for power long lines and low short circuit power for voltage to increase by 20 percent. If not controlled the line overvoltage will minimize the life span of insulation material and results in system faults.

Shunt reactors are located at the ends of high or extra voltage transmission lines, at some installations they are isolated during the period of high circuit loading. Shunt reactors they are classified into two types, dry type and oil immersed type reactors. Dry type reactors have lower operational costs and lower losses, usually they are installed to the tertiary winding of the transformer that is connected to the high voltage line to be compensated and their rated voltage is limited up to 24.5 kilo volts with also kilo-volt ampere rating. Oil immersed reactors mostly are connected to one or both ends of transmission lines and the voltage is not a limitation, as they are used for the line connection to control the voltage of the line..

In power systems, transmission lines are conductors that are designed to carry high and extra high voltages to transmit power over a short, medium and long distance but as the length of the line increases Ferranti effect occurs due to directly proportional of line length increases with the capacitance of the line. In power system, transmission lines plays critical role in the part of the economy, they increase the revenue of the active power and reduced the costs due to high reliability, low maintenance costs ; low internal losses that reduce the operating costs (ABB, 2017). Transmission lines are the sets of conductors that carry electrical power from the generating stations to the substations to deliver the power to the customers

2. SHUNT REACTOR

Transmission traces bodily combine the producing plants output and necessities of the clients with the aid of imparting the electricity float amongst the distinctive circuit in energy systems. For a electricity device transmission line is regarded to have sending and receiving end, and to have collection resistance, inductance and shunt inductance and the conductance as foremost parameters. The lengthy transmission is greater than 250 km and it has uniformly dispensed parameters.

Transmission line transmits bulk electrical strength from sending give up to receiving stop stations barring presenting to any purchaser and it can be divided into two predominant parts foremost and the secondary. The transmission voltage is boosted by means of the step-up transformer to a voltage of 132 kV or four hundred kV or 765 kV and when the electrical energy reaches its vacation spot at the receiving substation the voltage is stepped down for distribution to sixty six kV or 33 kV or 22 kV or eleven kV. The secondary transmission it varieties the hyperlink between the foremost receiving give up substations and secondary substations. In the transmission line the voltage can varies as a lot as 10 percentage or even 15 percentage due to variant of loads.

Shunt reactors are comparable to energy transformers, however they have solely one winding per phase.

Those three windings are big name related with the impartial factor reachable (YN). The impartial factor is linked to the earthing machine of the set up thru the tertiary winding of a electricity transformer or directly. Figure 5 indicates a regular connection format of a shunt reactor.

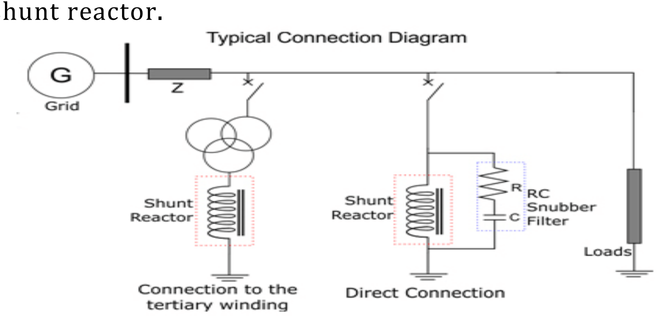

Figure 1 – Typical connection format of a shunt reactor

Shunt reactors may additionally be oil-immersed kind with conservator or dry type.

The built-on protections are the equal used in energy transformers (Buchholz relay and oil strain and temperature sensors for oil-immersed type; windings temperature probes for dry type). Accessories are additionally comparable to these used in energy transformers, primarily in oil-immersed type, in which it should be emphasised the oil strain comfort valve and the air breather.

Common shunt reactors have a fixed ranking (MVAr ; kVAr) and they may additionally be completely linked to the network, or switched in and out, relying on the load and of the capacitance of the underground cables in service. This functioning and the switching in and out are comparable to what is achieved with capacitor banks.

The extra current technological know-how calls, relying of the traits of the community and the variability of the load, for the use of variable shunt reactors (VSR), which ranking can be modified with the aid of steps. Common shunt reactors are ordinarily used in medium voltage networks (up to 36 kV).

VSR are basically used in greater excessive and excessive voltage networks (rated voltage of the community ≥ 60 kV).

Maximum rated voltage of shunt reactors is in modern times 800 kV and rated electricity goes up to 300 MVAr. Same like energy transformers, shunt reactors can also be designed like Oil-immersed and Dry kind transformer as well.

3. FAULTS IN REACTORS

Cross he modes of failure vary from air-core to oil-immersed designs and this impacts their safety necessities and schemes.

Fault kinds in Dry-type reactors Three sorts of faults show up in dry-type reactor installations

- Phase-to-phase faults on the tertiary busbar, ensuing in excessive magnitude segment current.
- Phase-to-ground faults on the tertiary busbar, ensuing in a low-magnitude floor current, based upon the dimension of the grounding transformer floor resistor.
- Turn-to-turn faults inside the reactor bank, ensuing in a very small trade in section current.

Phase-to-phase faults are a low chance fault for dry-type reactors due to the fact the reactors are single-phase gadgets with noticeably vast spacing between phases. The major reason of these segment to-phase faults is when arcing from a failed reactor is now not detected quickly sufficient and the fault ionization strikes up into the tertiary bus bar ensuing in a section to segment fault. Since dry-type reactors are set up on insulators which supply widespread clearance and insulation to ground, direct winding-to-ground faults are low chance as nicely and are produced solely when this impartial insulation is bridged by, for example, an animal. Damage finished by way of a winding to floor fault is decided through the grounding transformer/resistor impedance. Turn-to-turn insulation disasters in dry-type reactors commence s monitoring from insulation deterioration. Once the arc is initiated, these failures, if now not detected quickly, cascade to the complete winding due to the fact of the arc's interplay with the reactor's magnetic field. If the reactor financial institution is ungrounded, the modern-day in the wholesome segment will amplify to ٣ instances everyday segment contemporary and may want to thermally injury the un-faulted phases of the reactor bank.

Fault kinds in oil immersed reactors

The oil-immersed reactor faults are damaged into three categories:

- High modern-day phase-to-phase and phase-to-ground faults.
- Turn-to-turn faults inside the reactor winding.
- Miscellaneous disasters such as loss of cooling or low oil.

Because of the proximity of the winding with the core and tank winding-to-ground screw ups can occur. The magnitude of this fault decreases as the fault is positioned nearer to the impartial aspect of the reactor. Turn-to-turn faults begin out as a small alternate in segment currents however enlarge working temperature inner pressure, and accumulation of gas. If these are no longer shortly detected, they will evolve into a fundamental fault.

Failure charges of shunt reactors

The definition of failure charges yields;

Failure fee = no of disasters / (total populace * complete unit years)

Actual failure price information for reactors is no longer usually stored via utilities. Failure quotes of shunt reactor may additionally fluctuate giant from utility to utility in distinctive nations and is affected by using design, satisfactory and workmanship. For instance a failure price between ٠.٥-١.٠% of shunt reactors, may additionally extend to numerous percentage all through giant growth of the grid. Yearly preservation of the shunt reactors and bushings will maintain the failure price down.

Data from Canada and India suggests the distribution of disasters can for instance be about ٣٠-٤٠% bushing related, ٣٠-٤٠% winding related, ١٥-٢٠% magnetic circuit, ١٠- ١٥% terminals, and the failure origins may additionally be allotted as ٨٠% dielectric, ١٠% thermal, ١٠% mechanical or others like unknown, chemical, geomagnetic caused currents.

Turn to flip faults

Phase to Phase and Phase to Ground faults can be triggered by using turn-turn faults. The vicinity of the turn-turn fault is most in all likelihood in the windings closest to the excessive voltage section of the shunt reactor, brought on by using for instance an impulse voltage from electrostatic discharge like lightning storms. Each winding on the shunt reactor can be considered as an inductance parallel with a leakage capacitance and capacitance to ground. The inductive phase acts stiff on inrush currents, and the capacitive phase motives an exponential distribution of voltage over the winding, with max at the pinnacle due to excessive frequency.

The capacitive phase consists of the insulation fabric e.g. paper. If the very best voltage distinction between the windings on pinnacle of the shunt reactor exceeds the capacitive insulation level, the insulation cloth deteriorates and motives a turn-turn fault between two windings. A feasible way to defend for this is to sketch the shunt reactor with extra insulation in the pinnacle and equip the machine with a surge arrester, to restriction excessive currents.

Earlier issues with oil containing copper used in shunt reactors and transformers induced turnturn faults, nowadays with upgrades in oil quality, this distinctive hassle has disappeared.

Another reason of the turn-turn fault is vibrations. Vibrations create insulation fabric fatigue which in flip reduces the stage of insulation and can motive a turn-turn faults. Samples from oil and cloth should inform the situation of the shunt reactor insulation.

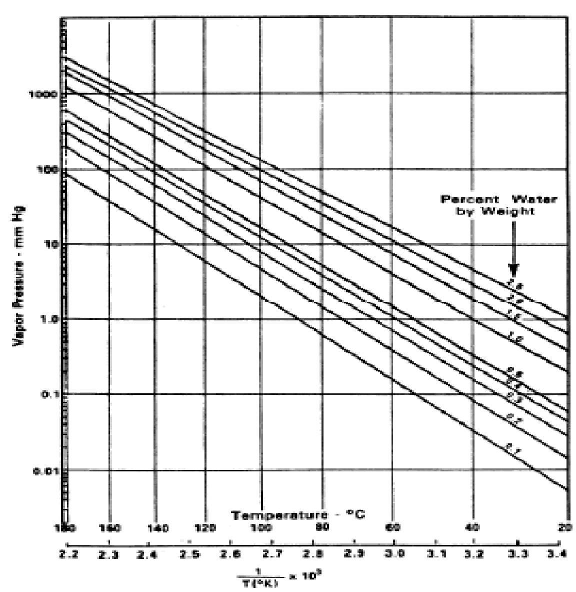

Figure 2 Equilibrium chart pertaining to water vapor stress over oil to water attention in insulation (kraft) paper vs. temperature.

Turn-turn faults can additionally be brought about via immoderate water in insulation paper, which can provide increase to water vapor bubbles when temperature increases, for this reason growing a low dielectric energy location main to electric powered arc. The most important threat for short-time disasters is the discount in dielectric electricity due to the viable presence of fuel bubbles in a location of excessive electrical stress, which are the windings and leads. This indispensable temperature will limit as the moisture awareness increases.

The chance with immoderate water in insulation paper can be mitigated by means of the usage of an on line monitoring machine with algorithms to decide water content material in paper and effervescent temperature, so as to difficulty warnings when the reactor is shut to a risky condition, earlier than a turn-turn fault happens.

Bushing failure

Overvoltage due to lightning impulses or even due to the reactor switching can carry about very excessive dielectric stresses to the reactor bushings. Specifically in case of externally generated overvoltage, the bushings will be the first ones to suffer the stress. This truth can lead to bushings insulation deterioration, which subsequently would purpose a phase-ground fault with extreme damages to the reactor itself or even to neighbor gadgets due to porcelain shards..

4. INVESGTIGATION

On receiving of the reactors at OEM works, investigation for failure evaluation the use of RCA TOOL done.

Root purpose evaluation (RCA) is the procedure of discovering the root motives of issues in order to become aware of splendid solutions. RCA assumes that it is a lot extra fantastic to systematically stop and resolve for underlying issues.

Root reason evaluation can be carried out with a series of principles, techniques, and methodologies that can all be leveraged to become aware of the root motives of an match or trend. Looking past superficial motive and effect, RCA can exhibit the place strategies or structures failed or brought on an problem in the first place.

After level 1 RCA analysis probable causes of arcing phenomenon analyzed.

Sl no	Probable Causes	Evidence	Remark
1	Service Cell feedback & Site system data	System data logs reviewed and found to be in order	Cause ruled out
2	Damages in active part	No physical damages observed in active part	Cause ruled out
3	Shorting of winding conductors	Low voltage tests on winding conducted and results found as per requirements	Cause ruled out
4	Local hot spots in core	All parts of core visually inspected and generally found in order	Cause ruled out
5	Loose connections	All electrical connections were found intact	Cause ruled out
6	All brazed & crimped joints	No Blackening observed at brazed & crimped joints	Cause ruled out
7	Presence of foreign particles	Not found during investigation.	Cause ruled out
8	Insulation (Core to earth part) failure	Withstood Isolation test satisfactorily	Cause ruled out
9	Lead metallisation sharp edges	Lead insulation opened & found satisfactory	Cause ruled out
10	Bushing half connector contact surface	Inspected. No chattering observed. Surface found smooth	Cause ruled out
11	Reactor oil	Oil parameters including BDV was tested before filling and found to be in order	Cause ruled out
12	Electrical clearances between Live & earth part	All minimum clearances measurement was done and found satisfactory	Cause ruled out
13	Copper & CRGO material	Supplier Test Certificates/source inspection records for copper & CRGO verified and found in order. No abnormality observed during inspection	Cause ruled out

14	VPD process, Site processes	Records for temperature, Vacuum, moisture removal from pressboard insulation investigated and found to be as per procedure	Cause ruled out
15	Peripheral earthing (Core clamp, Shunts etc.)	All earthing connections checked and found intact	Cause ruled out

5. CONCLUSIONS

Since all possible causes ruled out, it was decided to comprehensive dismantling of full active part including top yoke removal, Removal of top insulation items, top ring, removal of windings and other associated items of active part assembly.

Following observations found on dismantling:

- Stage wise dismantling of active part was done.
- Physical investigation was done to ascertain the root cause.
- No abnormality observed in active part from outside.
- Core was found healthy.
- Windings were removed from leg to check abnormality.
- **Blackening was observed in shield cylinder near earthing lead.**

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