CAUSES AND IMPACTS OF PROTECTION FAILURE DUE TO POWER DISTRIBUTION SYSTEM

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ABSTRACT

The distribution system is commonly broken down into three components: distribution substation, distribution primary and secondary. At the substation level, the voltage is reduced and the power is distributed in the smaller amounts to the customers. Consequently, one substation will supply many customers with the electric power. Thus, the number of the transmission lines in the distribution systems is many times that of the transmission systems. Furthermore, most customers are connected to only one of the three phases in the power distribution system. Therefore, the flow of the power on each of the lines is different and the system is typically 'unbalanced'. The electrical components in the power distribution systems are divided into six groups including overhead lines, underground lines, protective equipments, power transformers, distribution transformers, and capacitors. The failure of power distribution system may be due to failure of distribution transformers, mechanical damages, electrical circuits, magnetic circuits etc. that may lose the protections.

1. INTRODUCTION

The purpose of an electrical power generation system is to distribute the energy to a multiplicity of the points for diverse applications [1]. The system should be designed and managed to deliver this energy to the utilization points with the high reliability and adequate economy [2]. Reliability can be defined as the probability that a device or a system will perform a given task under the specified environmental condition for a specific period of time, while availability is that, a system will be able to perform its required function over a specific period of the time [3].

The distribution system is commonly broken down into the three components: distribution substation, distribution primary and secondary [4]. At the substation level, the voltage is reduced and the power is distributed in the smaller amounts to the customers. Consequently, one substation will supply many of the customers with the electric power. Thus, the number of the transmission lines in the distribution systems is many times that of the transmission systems. Furthermore, most of the customers are connected to only one of the three phases in the distribution system. Therefore, the flow

of the power on each of the lines is different and the system is typically 'unbalanced'.

The main function of the electrical power distribution systems is to provide power to the individual consumer premises [5]. Distribution of the electric power to different consumers is done with much low voltage level. Distribution of the electric power is done by the distribution networks. Distribution networks for the power supply consist of following main parts:

1. Distribution substation
2. Primary distribution feeder
3. Distribution Transformer
4. Distributors
5. Service mains

Often it is found the failure due to some of the faults in the Power Distribution System. The fault prediction for the failure in the Power Distribution System based on the early identification of symptoms, or incipient faults, leading to the appearance of faults is a topic of interest in power systems and several frameworks are available. The failure in the Power Distribution System often comes due to several causes those are transformer problem, mechanical damages, electrical circuits, magnetic circuits, lighting etc.

2. FAILURE OF POWER DISTRIBUTION SYSTEM

2.1 Transformer Breakdown

Transformers are one of the most important components of a distributed power system and can pose a lot of complicacies if they breakdown. Transformer problems normally are caused by the insulation oil degradation, overload, thermal stress, humidity in oil/paper and bushing defective and etc. [6]. Though the voltage transients and faults can impose a lot of stress on the transformers and its windings, overloading the transformer seldom leads to a breakdown. However, they can considerably weaken the thermal insulation and accelerate the ageing process of the transformers. From the records it may be stated that some of the causes are due to the contaminated oil. This is when they contain the moisture or other foreign substances that are not products of oil oxidation. One or a combination of the following can cause the elevated temperature: excessive load, excessive ambient temperature, cooling system problems, sludge oil, dark coloured exterior paints. Load and ambient temperature are closely related in their effect on the transformer operating temperature [7]. For the constant transformer load, the higher ambient temperature led to higher operating temperature. A number of the cooling system problems can cause a high operating

temperature: closed radiator valves, dirty cooling fins, broken or improperly set cooling fans/pumps, and the cooling control circuit failure [8].

FIGURE 1: TRANSFORMER BREAKDOWN

Excessive heat in a transformer can invariably weaken the insulating materials, making it brittle over a period of time, before it finally breaks it. For every 10°C rise in the temperature, the proximity of a thermal breakdown, also known as "Monstinger Factor," almost doubles resulting in the rapid ageing of the transformer. Also, once the insulation gets a brittle enough and the fault current flows through the windings, they literally shake and get cracked down. This in turn may lead to the transformer breakdown.

It should also be noted that even in the liquid filled transformers, extreme hot-spot temperatures can result in transformer failure [9]. The reason being, hot-spots are prone to generate the air bubbles, which are capable of decreasing the dielectric strength of the insulating liquid in the transformer leading to its failure [10].

2.2 Mechanical Damage in Transformer

Following are the causes of mechanical damages in Transformer:

1. The welding of the main tank may be defective and also the fillings may not be leak proof. This causes oil to leak reducing the oil level in the transformer causing heating of the winding and leading to a certain break-down of the equipment. Rough handling during the transport may also contribute to the leakage.
2. The LT terminals connected through the cables to LT take off lines. If these cables are not properly wired through the wooden cleats they cause some loading on LT Bush rods and finally results to burnt out.
3. Deposits of the coal dust, saline or chemicals on the bushing may cause a flash over, as the bushings will lose their insulating properties.
4. Sufficient place around a transformer to dissipate the heat must be provided. If the two transformers are kept close the surfaces may get clogged and oil temperature increases endangering to coil insulation.
5. Vapours at the top of the oil cooled transformers, may be explosive.

Bringing naked lamps at the places may cause damage as we can see in figure 1.

2.3 Electric Circuit failure in Transformer

Following are the causes of Failure of Electric Circuit in Transformer:

1. Moisture entering the tank by breathing action of the transformer reduces the di-electric strength of oil. The results in the breakdown from the coils or terminal leads to tank or core structures. The greatest damages is however the inter turns short in the coils of the transformer.
2. Deterioration of the oil may occur due to the prolonged over loading of the transformer. This action is aggravated by the presence of the copper and lead. When the oil temperature increases formation of sludge, water and acids are accelerated.
3. Certain amount of the oil is lost due to evaporation and oxidation while the transformer is in service. Periodical topping up of the oil level with the fresh tested oil is necessary, leads to unit gets over heated.
4. Narrow oil ducts and improper ventilation reduces the useful life of a transformer. Oil insulation turns into brittle and may get punctured.
5. Sometimes the clearance, provided between phases is insufficient. Also the insertion of the press board barriers may aggravate as they may up set the di-electric stress to throw too much stress across the coil spaces and across the barriers.
6. Wooden ducts provided for taking the terminal leads over them that should be properly dried. These may cause the short circuit between tapping leads.
7. Presence of the foreign particles in oil reduces the di-electric strength of the insulating oil and may cause a flash over resulting in the serious breakdown of the transformer.
8. When the acidity value of the oil increases, it will promote the oxidation of the metal parts and results in a breakdown.

2.4 Magnetic Circuit failure in Transformer

Following are the causes of Failure of magnetic circuit in Transformer:

1. The laminations are clamped together by inserting the bolts through core and yoke. The bolts are provided with the insulation around them which may give way. This total amount to a short in lamination causing the local eddy currents. When this trouble occurs, in due two bolts

simultaneously they form a short circuit turn through which the magnetic flux passes. If one of the bolts situated at the ends of the limb fail simultaneously they form a short circuit turn through which the magnetic flux passes. If one of the bolts situated at the ends of the limb that fails simultaneously with an adjacent bolt-in-the yokes. The patch between the two bolts is threaded by almost the entire value of the magnetic flux when passing from the core to yoke. The heat generated is so severe to cause a distortion of the whole core also causing a charring of the insulation and a resultant short circuit between the turns of adjacent windings.

2. Failure may occur of the insulation between the lamination and insulation between yoke clamping bolts fails. This registers the increment in the iron losses of the transformers.
3. Core clamping bolts should be securely tightened and locked lest vibration will set up causing the damage of core insulation and produce failures.
4. Care should be taken to ensure that the edges of the core and yoke lamination do not develop burns which may in turn produce local short circuit in the lamination.
5. No metallic fillings should be allowed to be present in between the lamination in finished transformers which causes short circuit.

2.5 Lighting Effect in Transformer

A lightning strike occurs when the voltage generated between a cloud and the ground exceeds the dielectric strength of the air. This results in a massive current stroke that usually exceeds to 30,000 amps. To make the matters worse, most strokes consist of the multiple discharges within a fraction of a second. Lightning is the major reliability concern for the utilities located in high keraunic areas. Lightning can affect the power distribution systems through the direct strikes (the stroke contacts the power system) or through indirect strikes (the stroke contacts something in close proximity and induces a travelling voltage wave on the power system).

FIGURE 2: LIGHTING EFFECT IN TRANSFORMER

3. DISCUSSION

After studying section 2, we found there are several failures that caused due internal or external factors. We found almost all the parts in a transformer liable to failure on opening a failed transformer it is often very difficult to say definitely the reason for the failure as all evidence is eliminated by the very nature of the break down. Consequently the cause of the failures is only a matter of guess.

Transformers are critical links in the power systems, and can take a long time to replace if they fail. Through faults cause extreme physical stress on the transformer windings, and are the major cause of the transformer failures. When a transformer becomes hot, the insulation on the windings gets slowly breakdown and hence becomes brittle over time. The rate of the thermal breakdown approximately doubles for every **10°C**. Because of this exponential relationship, the transformer overloads can result in rapid transformer aging. When the thermal aging has caused insulation to become sufficiently brittle, the next fault current that passes through the transformer will mechanically shake the windings, a crack will form in the insulation, and an internal transformer fault will result.

Also, the transformer failure could be due to electric circuit failure that may have some barriers which could result in failure of the transformer circuit similarly magnetic circuit could be due to some internal problem such as insulation between lamination, insulation between yoke clamping bolts fails, no metallic fillings etc. that cause the failure of transformer simultaneously Power Distribution system. Similarly, the lighting can cause increment in the temperature of the Transformer which in turn causes failure of Transformer.

4. CONCLUSION AND SUGGESTIONS

Conclusion

In this paper, the main causes of incidences and failures in the power distribution systems have been explored. As the demand for the electrical power is increasing day by day, the distribution system plays an important role in

catering the needs of consumers. For the reliability in maintaining the un-interrupted power supply one must have an efficient distribution system. The failure of a distribution transformer leads to the breakdown in power distribution system to all the consumers. Therefore the reliability in the power distribution system mainly depends on the reliable functioning of the distribution transformer. The failures in the Power Distribution System often comes due to several causes those are transformer problem, mechanical damages, electrical circuits, magnetic circuits, lighting etc. which in turn causes several incidents.

Suggestions

1. Careful design and construction on the part of the manufacturer, without subordinating quality to competition in the market is necessary, on the part of the purchasers also the economic behind the purchase should not be arrive at by cost alone but by performance guarantee.
2. Timely preventive maintenance is the back bone for the safe and efficient operation of any electrical equipment such as transformer the maintenance scheduled as well as the construction standards drown up by the APCPDCL are exhaustive enough to detect and prevent a possible failure ahead. If these are adhering it may be possible to reduce the failures to the large extents.

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6. REFERENCES

[1] Basic of Protection System, Available at: http://www.sayedsaad.com/Protection/files/Basic/01_basic.htm

[2] Power System Protection, Available at: http://dl.lib.mrt.ac.lk/bitstream/handle/123/1760/92972%20Chap%201.pdf?sequence=3

[3] K. Kolowrocki (1994). “Limit reliability functions of some seriesparallel and parallel series systems,” Journal of Applied Mathematics and Computation, vol. 62, pp. 129-151.

[4] INRD NETWORK (2014). System Analysis of Load Flow in Radial Distribution Network Power, Available at: http://www.ijser.org/researchpaper%5CSYSTEM-ANALYSIS-OF-LOAD-FLOW-IN-RADIAL-DISTRIBUTION-NETWORK-POWER.pdf

[5] Ashraf Faraaz, Radial Electrical Power Distribution System, Available at:

http://www.academia.edu/10918337/Radial_Electrical_Power_Distribution_System

[6] MG Niasar (2015). Mechanisms of Electrical Ageing of Oilimpregnated Paper due to Partial Discharges, Available at: https://www.diva-portal.org/smash/get/diva2:786741/FULLTEXT01.pdf

[7] Selim Trabulus (1997). Cooling Technology of SF_6 Gas insulated high voltage power transformer, Available at: http://www.emo.org.tr/ekler/61fbfb28115cd7e_ek.pdf

[8] H. Borsi, E. Gochenbach and V. Wasserberg, Life time Extension of Transformers by On-line Drying, in 19th International Power System Conference (PSC 2004) Iran-Tehran.

[9] O. A. Quiroga, J. Meléndez, S. Herraiz (2011). Fault Causes Analysis in Feeders of Power Distribution Networks, Available at: http://www.icrepq.com/icrepq'11/619-quiroga.pdf

[10] Major Causes of Power System Failures, Available at: http://electrical-engineering-portal.com/11-major-causes-of-power-system-failures