Research Topic:

Causes of Electrical Failures of Distribution Transformers in Newkru Town

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Abstract

Distribution transformer is an integral component of a power system because it serves as a link between any utility's distribution network and the power delivered to homes, commercial facilities, industries, etc. They provide the final voltage transformation in the electric power distribution system, stepping down voltage used by the customers for lighting, heating, and operation of motor loads. The research aims to ascertain hand-on information about the causes of electrical failures of distribution transformers in Newkru Town. Data on the causes of electrical failures of distribution transformers in the study area was taken and analyzed. It was found that 50% of distribution transformers in the study area failed due to inadequate protection system. The research proposes alternative solutions in mitigating the problem.

Key words: Distribution transformer, electrical failure, Surge arrestor, earth electrode

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Chapter One

Introduction

Background

Distribution transformer is a static (or stationary) piece of apparatus by means of which electric power in one circuit is transformed into electric power of the same frequency in another circuit. It lowers the voltage in the primary circuit but with a corresponding increase in current in the secondary circuit. As power utility companies thinks of maximizing revenue collection from their operations, customer needs will demand that they reinvest in their distribution networks to guard against needless equipment breakdowns and failures. Equipment damage, especially distribution transformers, presents one of the greatest challenges to the Liberia Electricity Corporation (LEC).

The physical basis of a distribution transformer is mutual induction between two circuits linked by common magnetic flux. In its simplest form, it consists of two inductive coils which are electrically separated but magnetically linked through a path of low reluctance. In Liberia, distribution transformers mostly step down voltages from 22KV (on the primary sides) to 440 Volts between phases and 230 Volts between phase and neutral (on the secondary sides) delta-star windings.

Unlike power transformers which are rated in MVA and are meant for transmission purposes, distribution transformers are rated in KVA and are meant for distribution and utilization of electric power. Generally, power ratings of distribution transformers range from 50 to 1000 KVA. Distribution transformer is classified into different categories based on certain factors such as type of insulation – liquid immersed or dry-type; mounting location – pole, pad, underground; number of phases – single phase or three phase ;voltage class; and basic impulse insulation level (BIL). The basic components of a distribution transformer are laminated core, windings, insulating materials, transformer oil, tap changer, oil conservator, breather, and cooling tube. See Appendix for Figures 1, 2, 3 and 4 that show the different categories of distribution transformers.

Like all electrical devices, electrical faults also happen in distribution transformers which cause power outages .Consequently, immense inconvenience is incurred in network management and involves high expenditure in relation to repair or replacement. Therefore, it becomes important to protect them against electrical failures such that much life could be extracted from them.

Statement of Purpose

Distribution transformers are integral components of a power system because they serve as a link between any utility's distribution network and the power delivered to homes, commercial facilities, industries, etc. They provide the final voltage transformation in the electric power distribution system, stepping down the voltage used by the customers for lighting, heating and operation of motor loads.

However, the distribution transformers in the study area have persistently failed. This continuous failure of distribution transformer in the study area is of paramount concern.

Significance of the Problem

The persistent electrical failures of distribution transformers in the area of study have led to power outages in homes, hospitals, schools, factories, industries and other commercial facilities. As a result, the Liberia Electricity Corporation has experienced immense inconvenience in network management and high expenditure in relation to repair or replacement of distribution transformers. Therefore, it becomes important to protect these distribution transformers against electrical failures so that network management is improved and the need to repair or replace damaged transformers is minimized.

Objective

Distribution transformer is an important and expensive component in the operations of the Liberia Electricity Corporation as it is the link between the corporation's 22 KV medium voltage distribution lines and customers; knowledge of the actual status of the distribution transformer in order to evaluate its service performance concerning reliability, availability and safety is important.

Hence, this paper presents the causes of electrical failures of distribution transformers in the study area and proffers cogent recommendations to solving these problems.

Limitations

During the conduct of this research, the actual end users of electricity in the study area were not surveyed. The research was only focused on the distribution transformers at the Liberia Electricity Corporation's Bushrod Substation feeder line in the study area and covered only employees of the Liberia Electricity Corporation because it is the only service provider of electricity in Liberia .

Additionally, the lack of existing data on the history of distribution transformers failures at the Liberia Electrical Corporation in the study area served as a major constraint during the research.

Delimitations

This research does not review literatures that are non-electrical related causes of distribution transformers failures such as mechanical and environment causes. The research is limited to distribution transformers in the study area and employed both qualitative and quantitative research methodologies.

Twenty crew supervisors of the transmission and distribution division of the Liberia electricity Corporation's Bushrod Island substation were surveyed.

Chapter Two

Literature Review

This chapter reviews relevant literatures in line with research topic of the study area. It takes a greater insight into the methodologies, findings, and recommendations of these literatures.

Eduful & Mensah (2010) in their analysis of the protection integrity of distribution transformer in the Ashanti East Region, one of the operational areas of Electricity Company of Ghana (ECG) with high incidence of distribution transformer burnouts, reported that distribution transformer burnouts were due to careless use of copper links to replace blown HRC fuses and high ground resistance. Six hundred seventy six distribution transformers were taken from the substation and analyzed. The report furthered by recommending that the following measures be taken by the Electricity Company of Ghana: (a) keep reliable data on frequency of fuse blow outs (b) eliminate shortfall in the supply of the HRC fuses (c) maintain a healthy network to avoid short circuit and earth faults or (d) apply appropriate engineering approach in the use of the copper links. On the issue of reducing high ground resistance, the researchers recommended the use of Palm Kernel Oil Cake as agent to improving ground resistance values in areas where lightning arrestor's ground resistance is high.

Singh, Zadgaonk, & Singh (2014) researched the premature causes of distribution transformer in one of the regions of the state of Madhya Pradesh (M.P.), India. It was a case study on four distribution transformers which failed. Three of the four transformers were installed in rural areas and one in urban area. Two of those three transformers had the same specifications but different manufacturer. The research found that the main cause of failure is due to overloading/ unbalanced loading. The results of their research were verified by the Dissolved Gas Analysis (DGA). During this analysis, oil samples of twenty seven distribution transformers of different KVA ratings were studied. Breakdown Voltage (BDV), Total Acid Number (TAN), and Viscosity of the oil samples were measured and analyzed. The obtained results showed that the total acid number and viscosity increased significantly due to thermal aging and breakdown voltage (BDV) decreased substantially. The research recommended that monitoring of the Breakdown Voltage (BDV), Total Acid Number (TAN) and Viscosity of distribution transformer oil can appreciably reduce the premature failure of distribution transformers.

Ndungu, Nderu, Ngoo & Hinga (2017) reported that line surges and switching transients were key among the main causes of distribution transformers failures because they accelerate deterioration of insulation materials. It further noted that lack of lightning arrestors and vandalism of low and high voltage earthing systems. The report recommended that power utility avoid transformer overload by properly grading the low voltage fuses.

Chapter Three

Research Methodology

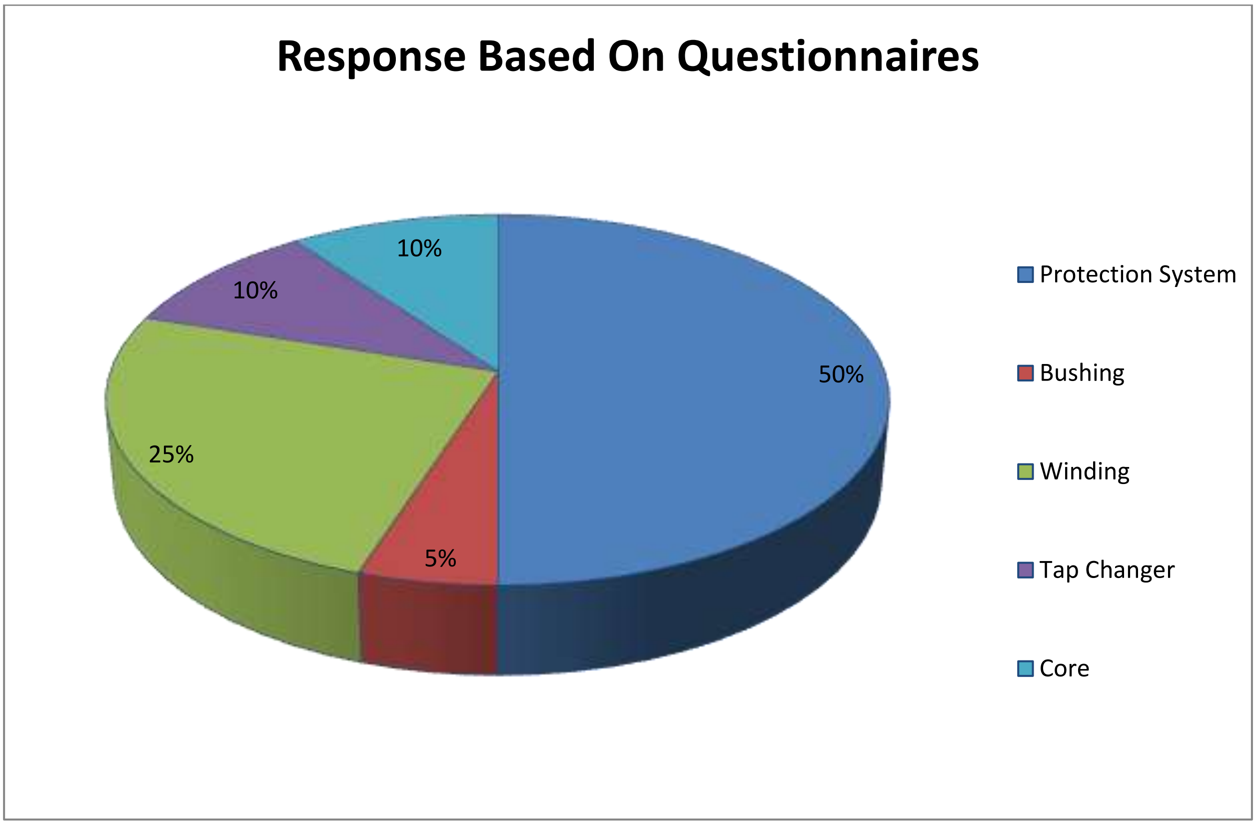
This chapter focuses on the research method, research design, population of the study, sampling procedure and sample of the study, data collection procedure, data presentation and data analysis process. The research was conducted to ascertain some hands-on information about causes of distribution transformer failure in the study area. Twenty (20) crew supervisors of the transmission and distribution division of the Liberia Electricity Cor8peration's Bushrod Island substation were surveyed. The aim of this survey was to inquire about the causes of electrical failures of distribution transformer and consequences. Details such as transformer type, causes of failure and consequences were collected.

Chapter Four

Discussion of Findings

Table 1.0 Response Based on Questionnaire

Types of Failures	Number of Respondents
Protection System	10
Winding	5
Core	2
Tap Changer	2
Bushing	1



Findings

Data on the causes of electrical failures of distribution transformers in the study area was taken and analyzed. As illustrated in the pie chart, 50% of the respondents (crew supervisors) attributed the electrical failure of distribution transformers to inadequate protection system in the study area. The main factors that led to inadequate protection system are as follow:

- Improperly graded low voltage fuses
- Substandard electrical engineering approach in sizing circuit breaker
- Inadequate earth electrode due to high soil resistivity
- Unhealthy network and faulty lightning/surge arrestors

Chapter Five

Conclusion

Distribution transformers are integral components of a power system because they serve as a link between any utility's distribution network and the power delivered to homes, commercial facilities, industries, etc. They provide the final voltage transformation in the electric power distribution system, stepping down the voltage used by the customers for lighting, heating and operation of motor loads.

However, results from the research have established that inadequate protection system is the major cause of electrical failures of distribution transformers in the study area.

Chapter Six

Recommendation

It is recommended that the following protective measures be taken by the Liberia Electricity Corporation so as at improve its protection system:

- The use of properly graded low voltage fuses to avoid overload
- Keep reliable data on frequency of fuse blowouts and avoid shortage of HRC fuses
- Use standard electrical engineering approach in sizing circuit breakers
- Improve earth electrode resistance in areas of high soil resistivity by either treating the soil with gents such magnesium sulfate, copper sulfate, and ordinary rock salt, lengthening of earth electrode or using multiple rods
- Maintain a healthy network to avoid short circuit and earth faults and conduct routine check on surge/lightning arrestors

Appendix

Figure 1: pole-mounted three phase distribution transformer

Figure 2: pole-mount single phase distribution transformer

Figure 3: Three Phase Distribution Transformer

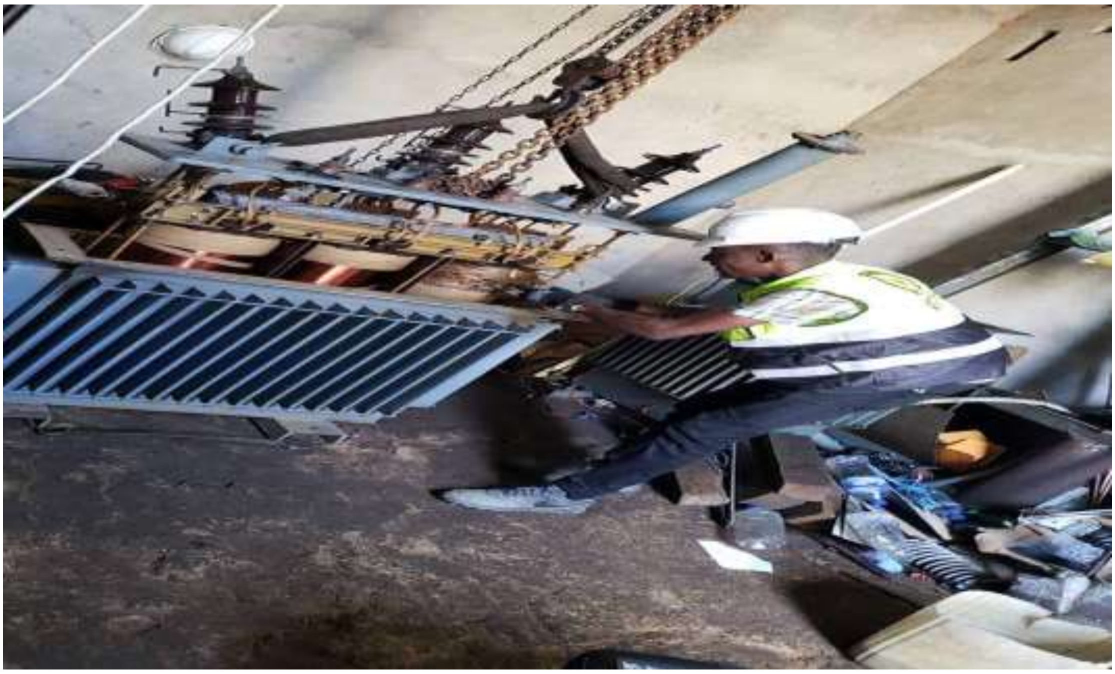


Figure 3: three

Figure 4: surge arrestor of a three phase distribution transformer

References

- Mehta, V.K. & Mehta, R. (2006). Principles of Power System. India: S.Cand Publishing

- Eduful, G. & Mensah, G. (2010): An investigation into Protection Integrity of Distribution Transformers - A Case Study

- Singh, R., Zadgaonkar A.S, & Singh (2014): Premature Failure of Distribution Transformer- A Case Study

- Taikina-aho. M (2010): Survey of transformer failure, causes and consequences

- Tariq Jan, S., Afzal, R., & Akif Zia Khan, A.(2015): Transformer Failures, Causes & Impact

- Ndungu, C., Nderu, J., Ngoo, L.& Hinga, P. (2017): A Study of the Root Causes of High Failure Rate of Distribution Transformer - A Case Study