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POWERING THE FUTURE: EXAMINING THE SUBSTATION EQUIPMENT AND POWER TRANSFORMERS AT SUBSTATION

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ABSTRACT

This mini project aims to analyze and evaluate the performance of substation equipment and Power Transformers. Lightning Arrestor, Power Transformers, Potential Transformer, Current Transformer. Bus-Bar, Isolator, Circuit Breaker Batteries, Capacitor Bank, Indicating and metering Instruments, Relay and Insulator are some of the substation equipment. Power Transformers are crucial components of electrical substations, responsible for voltage transformation and efficient power transmission. A combination of theoretical analysis and practical investigation will be employed in this mini project. The theoretical aspect will include on in-depth literature review to understand the fundamental principles of power transformer operation, factors influencing their performance and existing analysis techniques. The practical aspect will involve data collection from the substation, such as transformer specifications, load data and historical maintenance records. Through data analysis, this may involve assessing parameters such as voltage regulation, losses, and thermal behavior. This project will explore maintenance practices and condition monitoring techniques implemented by power transformers, aiming to identify areas for improvement and optimization. The outcomes of this mini project will provide valuable insights into the role and performance of power transformers at Chandrayangutta 220/132 KV Substation, enabling a better understanding of their contribution to the efficient and reliable power supply. The findings can support decision making processes related to maintenance strategies, system upgrades, overall grid stability. ultimately facilitating the powering of the future with enhanced efficiency and reliability.

INTRODUCTION

Electricity is created in power plants, which are often located in remote areas since this is the most efficient place for them to be in from consumers. An broad transmission and distribution network makes it easier to distribute the product to the end users, who are known as customers. Altering the characteristics of the electrical supply, such as its voltage, frequency (by switching from AC to DC), power factor, and in certain cases even other aspects, may be necessary at a number of places across the architecture of the power system. This may also be justified. This is made possible by the use of an appropriate gadget that is referred to as a substation. As an example, the voltage that is produced at the power station, which is normally 11 kilovolts (kV) or 6.6

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kilovolts (kV), goes through a step-up procedure in order to achieve a higher voltage level, such as 220 kilovolts (kV) or 132 kilovolts (kV), which makes it easier to transmit electric power. The sub-station is the location where the different pieces of equipment, such as transformers, that are required for the performance of this task are assembled. In a similar vein, it may be essential to lower the voltage to a level that is appropriate for usage in real situations in close proximity to regions that are inhabited by customers. Once again, the process is carried out by an apparatus that is suitable for the job and is called as a Sub-Station.

I. LITERATURE SURVEY

Cooling of Transformers and Methods of cooling

The term "cooling" is used to describe the process by which the heat that is generated inside of a transformer is either dissipated or regulated so that it may be maintained within acceptable parameters. Utilizing a variety of cooling systems helps bring about cooling in transformers, which is made possible by these technologies. The existence of many losses, such as hysteresis, eddy current, iron, and copper losses, is the fundamental factor that causes heat to be produced by transformers. The copper loss, commonly referred to as the I2R loss, is the principal factor responsible for the creation of heat among the many other types of losses. If the temperature within the transformer continues to increase at a rapid pace, this will cause the insulating material that is utilized inside the transformer to deteriorate, which will in turn cause damage to the multiple components that make up the transformer, which will finally result in the failure of the transformer. As a result, it is very necessary to remove or treat heat in an effective manner in order to guarantee the transformer will perform properly, will have a longer lifetime, and will be more efficient. A wide variety of different substances, including as air, synthetic oils, mineral oils, gas, and water, are used as cooling mediums for the aim of bringing down the temperature of transformers.

The dry type and the oil immersed type are the two basic categories that may be used to classify transformers. The process of cooling transformers makes use of a wide variety of different types of cooling methods.

II. SUB-STATION EQUIPMENT

SINGLE LINE DIAGRAM

A Single Line Diagram (SLD) of an Electrical System is the Line Diagram of the concerned Electrical Systems that comprises all of the needed electrical equipment connection sequence wise from the point of entry of Power up to the conclusion of the scope of the specified Work. The SLD begins at the point where power first enters the system and ends when the work is completed. As is the case with 220KV Substations, the SLD must display the Lightning Arrestor, the Capacitive voltage transformer, the isolators, the Protection and Metering P.T&C.T. Clit Breakers, once again the Isolators, the Main Power Transformer, all protective devices/relays, and any other specialized equipment such as CVT, GUARD RINGS, etc., as specified by the design criteria. And a display of the symbols may be seen below. There are several fodders that enter into the substation and transport the electricity out. These feeds, when entering the station, are seen to go via a number of different devices.

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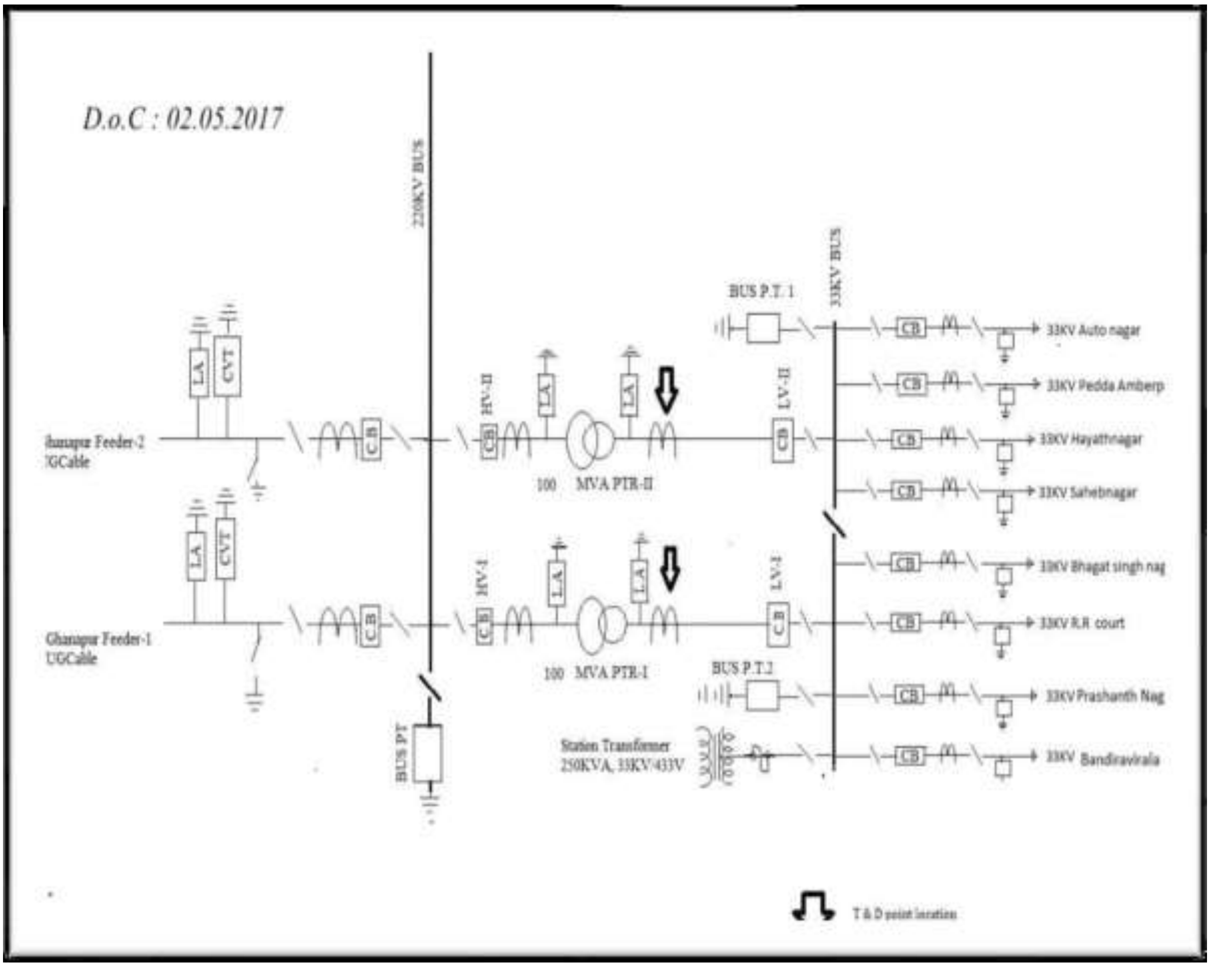

Fig. Single Line Diagram

COMPONENTS OF SUB-STATION

The equipment used in substations plays a crucial role in the management of energy flow and the preservation of grid stability. Transformers play a pivotal role in facilitating voltage conversion, whilst switchgear and circuit breakers serve the purpose of enabling control and safeguarding mechanisms. Relays serve the purpose of monitoring various circumstances and then initiating appropriate reactions, so augmenting both safety and dependability. Contemporary substation designs often include digital technology to provide increased monitoring, automation, and efficient operation. In its whole, this equipment serves as the fundamental framework of the electrical infrastructure, guaranteeing a steadfast and dependable provision of electricity to end-users.

1. Incoming Feeder
2. Line Isolator

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3. Relays:
4. Circuit Breaker

III. TRANSFORMER PRINCIPLE

A transformer is a stationary apparatus that facilitates the conversion of electrical power from one circuit to electrical power of equivalent frequency in another circuit. In an electrical circuit, it is possible to manipulate the voltage by either increasing or decreasing it. However, this adjustment is accompanied by a corresponding proportionate rise or drop in the current ratings.

The fundamental operating principle of a transformer is based on the concept of mutual inductance, whereby two distinct circuits are connected via a shared magnetic flux. A fundamental transformer has two electrically isolated and inductively coupled coils, which are magnetically interconnected via a reluctance pathway. The operational mechanism of the transformer may be understood by referring to the diagram shown below.

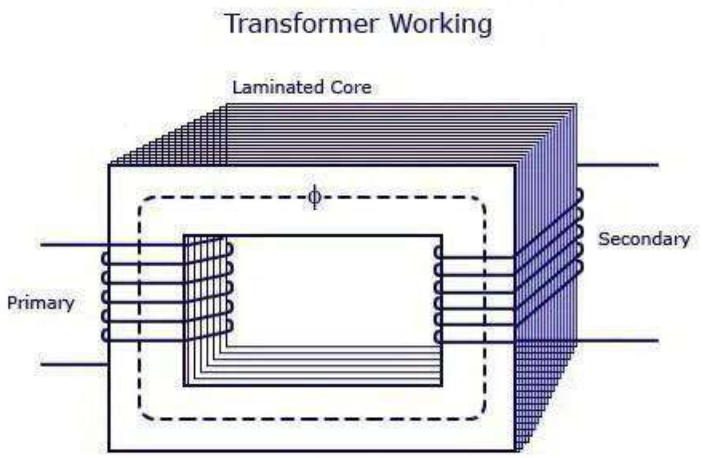

Fig. Trasformer Working

TAP CHANGING OF TRANSFORMERS

The primary function of a tap changer is to effectively control and adjust the output voltage of a transformer. This is achieved by modifying the number of turns in a certain winding, thereby adjusting the turns ratio of the transformer. There are two distinct categories of tap changers, namely the de-energized tap changer (DETC) and the on-load tap changer (LTC).

TRANSFORMER VECTOR GROUP CHECK TESTING

In order to conduct the Vector Group test, it is necessary to establish the electrical connection between the Primary and Secondary windings, since these distinct winding transformers are inductively connected. Once the electrical connection has been established between the two windings being tested, the voltage may be provided to either of the windings. It is recommended to apply the voltage on the high-voltage (HV) side, since this is considered safer. By measuring the voltage between the different terminals, one can determine the phase shift and verify proper functioning. The testing engineer is required to establish a minimum of three conditions in order to compare, add, or equal the specific set of voltages that are to be measured. The aforementioned requirements should be formulated in a manner that guarantees the attainment of both phase shift and

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phase sequence. If the necessary requirements are met, the vector will be validated.

Magnetic Balance Test Procedure

1. On the transformer, you have a primary high-voltage terminal (11/22/33kV, etc.) & Secondary low-voltage terminal (415/433/575/750 V, etc.),
2. Disconnect cables from both sides of the transformer.
3. Connect single phase 230 Volts supply between the first and second phase of the primary side of the transformer (between 1U & 1V)
4. Measure voltages between 1U~1V, 1V~1W, and between 1W~1U,
5. Similarly measure voltages between 2U~2N, 2V~2N & 2W~2N
6. Then connect the single-phase supply between the second and third phases on the primary side (between 1V~1W), and again record readings as mentioned in 5 & 6 above.

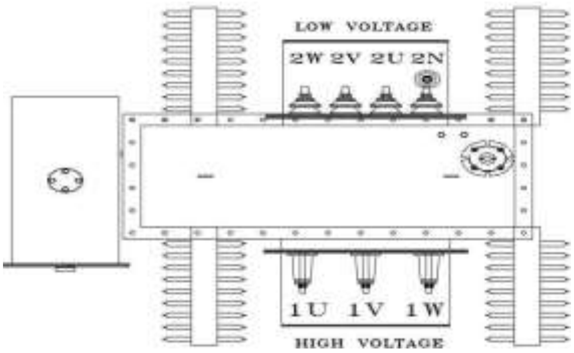

Fig. Distribution Transformer

IV. DIELECTRIC STRENGTH TESTING OF TRANSFORMER OIL

Oil Breakdown Test

The assessment of the insulation oil's state, sometimes referred to as transformer oil, involves conducting tests to determine its water content, breakdown voltage, and acidity levels. A ideal water content is one that is below 30 mg/kg. The dielectric strength of insulating oil is diminished by the presence of water. In order to prevent the occurrence of flashovers caused by the Avalanche Effect on the insulation, it is necessary for the Breakdown Voltage (BDV) to exceed 30 kV when voltages lower than the BDV are used. The acidity level should be below 0.15. The potential existence of sulphur or its derivatives may lead to corrosion of metallic components and an escalation in sludge formation.

Dissolved Gas Analysis (DGA) Test

The examination of dissolved gases The DGA test is used to extract gases from an oil sample and then analyze the composition of these gases in relation to the quantity of oil present. The analysis of the gas composition in oil may provide valuable insights on the condition of the transformer. The purpose of this experiment was to assess the internal state. The DGA test is used to analyze the proportion of flammable gases present in the oil of a transformer.

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HV AND LV ENERGY METER READING OF 160MVA AT THE POWER TRANSFORMER AT 220 KV SUBSTATION

Table. Energy meter reading in MVA

Time	(160MVA) PTR-I Energy Meter Reading		(160MVA) PTR-II Energy Meter Reading		(160MVA) PTR-III Energy Meter Reading		(160MVA) PTR-IV Energy Meter Reading	
	HV(MVA)	LV(MVA)	HV(MVA)	LV(MVA)	HV(MVA)	LV(MVA)	HV(MVA)	LV(MVA)
12:20	309311	300054	76620	115547	104798	132031	232239	218507
1:20	309374	300118	76677	115605	104857	132092	232302	218572
2:20	309430	300176	76728	115663	104913	132150	232462	218634
3:20	309486	300235	76780	115721	104970	132208	232423	218696
4:20	309548	300299	768376	115771	105039	132279	222498	218772

Table. Energy meter reading in MW

Time	PTR-I Load in MW		PTR-II Load in MW		PTR-III Load in MW		PTR-IV Load in MW	
	HV	LV	HV	LV	HV	LV	HV	LV
12:20	103.4	99.4	95.4	92.4	102.6	98.1	110.0	104.6
1:20	102.5	96.7	93.8	90.0	99.7	95.3	108.9	101.6
2:20	100.7	94.7	91.45	87.95	98.5	94.5	107.2	101
3:20	98.9	91.7	89.1	85.9	98.2	93.8	105.6	100.5
4:20	87	81	79	75	99.9	94.3	106	100

Table. Energy meter readings of HV and LV

Time	PTR-I		PTR-II		PTR-III		PTR-IV	
	HV	LV	HV	LV	HV	LV	HV	LV
12:20	104.58	102.4	94.62	92.8	97.94	97.6	104.58	104
1:20	92.63	92.8	84.66	92.8	92.96	92.8	99.6	99.2
2:20	92.96	94.4	86.32	92.8	94.62	92.8	101.26	99.2
3:20	102.92	102.4	94.62	80	80	113.6	128	121.6

Table. Hourly efficiency of all the 160MVA transformers

Time	Efficiency of PTR-I	Efficiency of PTR-II	Efficiency of PTR-III	Efficiency of PTR-IV
12:20	97.99%	97.75%	99.65%	99.4%
1:20	99.9%	99.9%	99.89%	99.59%
2:20	98.9%	99.81%	98.7%	97.6%
3:20	99.0%	85.1%	99.1%	94.53%

Transformer Efficiency Formula = output /output+ losses

V. CONCLUSION

In summary, the examination of the substation equipment and electrical transformers substation has yielded a number of significant discoveries. The transformers were seen to be in a satisfactory state and operating within acceptable limits, which is essential for maintaining their performance. Furthermore, a thorough evaluation was conducted on the substation equipment to determine its safety and functioning. Based on this assessment, recommendations were made for essential upgrades and repairs. These measures are crucial in order to maintain a proactive maintenance approach and implement continuous monitoring. The ultimate goal is to guarantee the efficient and reliable provision of electrical power in the area. Transformers have significant importance as essential components within a substation infrastructure. Power transmission and power distribution are both crucial aspects of electrical systems. Due to its crucial function in electrical power transmission, the transformer requires frequent maintenance. In the event of any errors or malfunctions, it is important to promptly identify and address them. In the event of a delay in rectifying a problem, it is plausible that a consequential catastrophic failure may occur, potentially resulting in significant economic losses for the energy department. The appropriate course of action must be undertaken and the defect must be rectified, depending on its kind. The use of essential equipment is imperative for the detection of faults and the safeguarding of the transformer. Thermal imaging cameras provide constant monitoring of the transformer's status and provide comprehensive data to distant operators. In the event of a defect, it is readily detectable at the first stage and may be promptly rectified within a short period of time. This approach allows the prediction of problems and implementation of appropriate steps to enhance the operational efficiency of transformers and extend their lifespan.

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