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Power Transformer For Residual Life Assessment

P.Pooja[1], Y.Sudha[2]

Assistant Professor, Department of Electrical Electronics Engineering,

Malla Reddy Engineering College, Hyderabad, India[1,2]

Abstract: Power Transformers are the most vital components in a sub-station / Receiving station. Failure of a Transformer leads to loss of revenue besides affecting reliability of power supply to consumers. It can lead to non availability of the transformer for long durations. In this paper, an approach to evaluate transformer‘s aging condition is introduced based on multi-parameters. Firstly, the different types of insulations in transformers like solid insulation and liquid insulation have been discussed. Later, the ageing process of these insulations used in transformer has been illustrated in detail. Different condition monitoring techniques used for transformer are included to assess the life of insulating material. A program is developed in Visual Basic Software which is very user friendly software. Through the developed program, we can predict the remaining life of transformer. Moreover, a software system based on transformer's electrical and thermal parameters is developed correspondingly, by using a multi- parameters analytic approach. This system is expected to help in planned maintenance of Transformer on fields. This can help the utilities in making optimum use of the transformers and also taking timely decisions regarding refurbishment / replacement of transformers. Various transformer insulation properties like electrical properties, oil quality and temperature are considered in assessment of remaining life of transformer.

Keywords: Transformer insulation, Insulation aging, Condition Monitoring, Dissolve gas analysis

I. INTRODUCTION

Power transformer is an electric device which is used to step up or step down the voltage level of the supply fed to its primary winding. The stepping up or down depends upon the number of turns of primary and secondary winding. If the number of turns on both the windings is same, and the losses of transformer are negligible, we may Conclude that the voltage across each of the winding is same. In this case the transformer is just utilized in isolating two electrical circuits. Generally power transformer is used in stepping up the voltage of the supply in order to decrease the transmission losses and then stepping.

These are mainly used in distribution side to interface step up and stepdown voltages. The life span of these type of transformers is around 30years.Based on ranges, the power transformers are classified into three types.

Small power transformers (500-7500KVA)
Medium power transformers (100MVA)
Large power transformers (100MVA and beyond)
These transformers transform the voltage and depend on the principal of faradays laws of induction. It holds a low voltage, high current circuit at one side of the transformer and on the other side of the transformer it holds the high voltage low current circuit.

II. POWER TRANSFORMER DESIGN

The skeleton of the power transformer is designed with metal which is laminated by sheets. It is fixed into either a core type or shell type. The skeletons of the transformer are wound and connected using conductors to make three 1-phase or one 3-phase transformer. Three 1-phase transformers requires each bank isolated from the additional and thus offer continuity of service when one bank flops. A single 3-phase transformer, whether the shell or core type, will not function even with one bank out of service.
The 3-phase transformer is inexpensive to make and it has a smaller footprint, and functions comparatively with higher efficiency.

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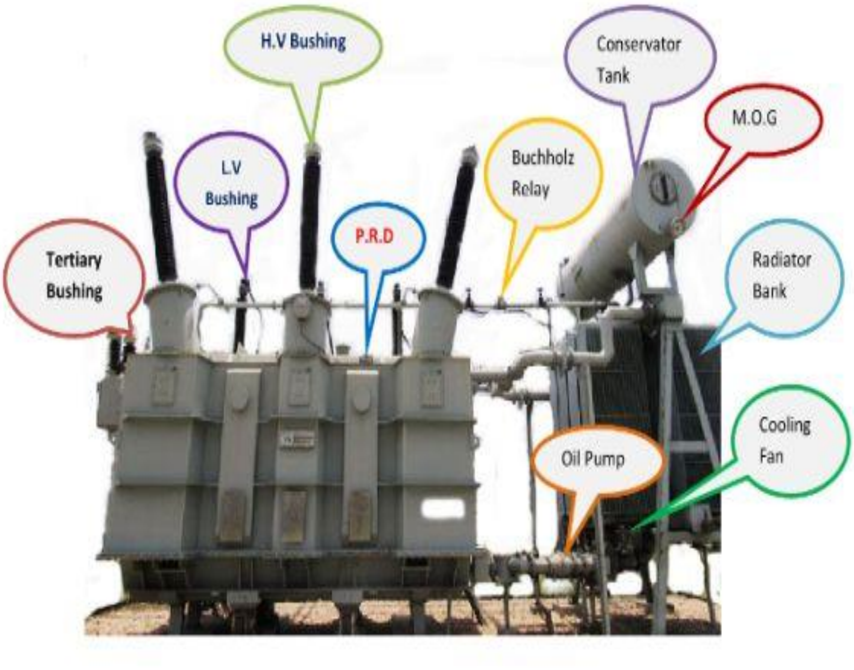

Power Transformer (160 MVA 220/132/33 KV Auto Transformer)

III.EXIXTING SYSTEM

It plays a very significant role of the transformer insulation system and has the important functions of acting as an electrical insulation as well as coolant to dissipate heat losses. Another main function of transformer oil is it act as a diagnostic tool of the transformer.
The basic raw materials for the production of transformer oil is a law viscosity lube termed as transformer oil base stock (TOBS), which is normally obtained by fractional distillation and subsequent treatment of crude petroleum. TOBS is further refined by acid treatment process to yield transformer oil. Power transformers undergo prolonged drying processes, using electrical self-heating, the application of a vacuum, or both to ensure that the transformer is completely free of water vapor before the insulating oil is introduced. This helps prevent corona formation and subsequent electrical breakdown under load.

Chemical composition

Transformer oil consists of four major generic class of organic compounds namely paraffins, Naphthene Aromatics and olefins. All these are hydrocarbons and hence insulation oil is purely a hydrocarbon mineral oil. For good fresh insulating oil, it is desirable to have more of saturated paraffins, less of aromatic and\or naphthenic and none of olefins. Depending upon the predominance, oil is usually termed as of paraffinic base or naphthenic base. This is carried out to ensure that these are within guaranteed limits. The test comprises of following:

1.Routine tests
2.Type tests
3.Special tests

Routine tests:
Measurement of winding resistance
Measurement of voltage ratio and check for voltage vector relationship
Measurement of insulation resistance
Dielectric tests

Type tests:

All the tests listed as above and the temperature rise test and dielectric type tests.

Special tests:
Short circuit test

Measurement of a caustics noise level
Measurement of surge voltages on low voltages windings
Measurement of harmonics of the no load current

The key concept of life assessment is serviceability i.e., the ability to function as intended. Life assessment studies aim at comparing and ranking transformers with respect to their suitability for use in a relative evolution procedure of several transformer. The serviceability is determined by actions taken before the transformer was taken into the service and from the history and events occurring in service. The area evaluated for serviceability are: Technical Serviceability: - Detailed evaluation advanced of electrical, mechanical and auxiliaries. On-Technical Serviceability: - Strategies in particular to economy and environment. Screening Evaluation: en by the fans and oil pumps. It is a prime task to sort out the units, the efforts can be concentrated on doubtful units..Monitoring technique system for a transformer is an evolving process due to change in technologies, improving understanding..

S.No.	Item	Tolerance
a)	Total losses 1. component losses	±10% of the total loss ±15% of each component loss, provided that the tolerance for total losses is not exceeded
b)	Impedance voltage at rated current 2. Principal tapping 2-winding T/F Multi winding T/F 2. For tapping's other than the	 ±10% 0f declared impedance voltage ±10% Of the declared impedance voltage for one specified pair of windings Tolerance shall be increased

Purpose of Monitoring Technique:
avoid forced outages
minimize failures
optimize maintenance costs
improve safety to personnel and environment.

IV. PROPOSED SYSTEM

The need for reliable and stable systems is being increasingly felt. Thus, emphasis is now being laid on 100% capacity utilization and the availability of equipment for reliable operation of the system. Fortunately, many tools are now available or underdevelopment, which can be used for condition monitoring of the transformer. With a view to cover detailed information about DGA and condition monitoring, wise residual life assessment, this chapter has been divided into two sectors: Dissolved Gas Analysis Interpretation.RLA And Refurbishment.Incipient faults in oil filled transformers are usually the result of electrical or thermal stresses in either the transformer oil or insulating materials. It is known that such excessive stresses produce a mixture of gases characteristics of which give an indication of the type of fault and location associated with the fault It is recommended that analysis of dissolved gases in transformer oil by gas chromatograph equipment's is made at the time of commissioning and then every six months for transformer s of 145 KV class and above.

Analysis method

Oil in transformers can be sampled through the drain or sampling valve near the bottom of the tank. Special care is to be taken not to introduce air, foreign matter, or dirty oil into the sampling container. For this purpose, first 0.5-1.0 litre of oil from the transformer is to be over-flown through the oil container. The oil sample must not be exposed to air before analysis Before taking total outage of transformer following preliminary physical inspection, tests should be carried out to establish the reason for the increasing trend of fault of fault gases.

Analysis of fault gases:
The gases to be analysed and the criteria for the gases found in the transformer oil are tabulated in below table.

Table: Analysis Method (S1)

S.no	Operating Condition	Gases to be analysed
1.	Normal	O_2, N_2, H_2, CO, CO_2, CH_4.
2.	Abnormal	H_2, CH_4, C_2H_2, C_2H_4, C_2H_6.
3.	Deterioration	CO, CO_2, CH_4.

The generation of gases in oil by some typical faults in transformer active part models are shown in given below.
Table: Analysis Method (S2)

S.no	Type of faults	Decomposable gases in transformer oil
1.	Arcing in oil	H_2, CH_4, C_2H_4, (C_2H_6, C_2H_2, C_3H_6, C_3H_8)
2.	Overheating of solid insulating materials	CO, CO_2, (C_2H_4, H_2)
3.	Overheating of oil and paper combination	CO, CO_2, CH_4, C_2H_4, H_2
4.	Arcing of oil and paper combination	H_2, CO, CO_2, CH_4, (C_2H_4)

V. TEST RESULTS

Ulr no.	Tc657920000000300p	Discipline : electrical testing	Group : insulating oil	Date	25.02.2020
REF :Power Grid					

Date Of Receipt At R & D Lab.	13.02.2020	Appearance :	CLEAR
Date Of Testing	19.02.2020	Condition Of The Sample On Project :	Good

Name And Designation : DEE, M Organization : APTRANSCO			Address :400KVSS nellore (dist) Phone/Email Id: 9440817621	
Transformer Details			Sample Details	
Station	400KVSS NELLORE		Date Of Sampling	12.02.2020
Tr No.	ICT-1		Oil Temperature(^{O}c)	62
Make & Capacity	ABB	315MVA	Date Of Last Filtration	04/2006
Si.No & Year Of Mfg.	14001-003	2005	Sample Point	BOTTOM
Voltage Rating	400/220kV		Sample Container	SS container
Date Of Commng.	29.04.2006			
Load at sampling (MW)	208MW			

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Reference standard as per IS : 1866-2016					Dissolved gas analysis as per test method IS 9434:992 RA 2013, IS 10593:2017		
Parameter	UoM	Violation limit	Measured value	Test method	Parameter	UoM	Measured value
B.D.V	Kv	60 min	81.0	IS6792	Total Combustile Gas	ml.	
Sp. resistance at 90ºC	Ohm-cm	1.0E12 min	NT	IS6103	Hydrogen(H_2)	Ppm	ND
Tan delta at90ºC	---	0.1 max	NT	IS6262	Methane(CH_4)	Ppm	4.5
Water content	Ppm	15 max	5.6	IS13567	Ethane(C_2H_6)	Ppm	1.9
Interfacial at27ºC	mN/m	28 MIN	NT	IS 6104	Ethylene(C_2H_6)	Ppm	7.8
Density at 29.5ºC	Mggm/cc	-	NT	IS 1448 P-16	Acetylene(C_2H_2)	Ppm	ND
Acidity*	KOH/g	0.1 MAX	NT	IS1448 P-1	Carbon Monoxide(CO)	Ppm	297.1
Flash point*	ºC	135 MIN	NT	IS1448 P-21	Carbon dioxide (C02)	Ppm	23362.0

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Acidity*	KOH/g	0.1 MAX	NT	IS1448 P-1	Carbon Monoxide(CO)	Ppm	297.1
Flash point*	ºC	135 MIN	NT	IS1448 P-21	Carbon dioxide (C02)	Ppm	23362.0

VI. CONCLUSIONS

This paper analyzes factors that affect transformer life and points out the uncertainty of factors. Considering the uncertainty factors, residual life evaluation model is set up based on Visual Basic Software which is very user friendly software and evaluates the residual life, which can provide support for transformer maintenance schedule and be benefit to the safe and economic operation of power system.

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