FAILURE ANALYSIS OF A POWER TRANSFORMER USING DISSOLVED GAS ANALYSIS – A CASE STUDY

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Abstract

Reliable and continued performance of power Transformer is the key to profitable generation and transmission of electric power. Failure of a large power transformer not only results in the loss of very expensive equipment, but it can cause significant guaranteed damage as well. Replacement of that transformer can take up to a year if the failure is not disastrous and can result in tremendous revenue losses and fines. A Power Transformer in operation is subjected to various stresses like thermal stress and electrical stress, resulting in liberation of gases from the hydrocarbon mineral oil which is used as insulant and coolant. Dissolved Gas Analysis is a technique used to assess incipient faults of the transformer by analyzing specific dissolved gas concentrations arising from the deterioration of the transformer. DGA is used not only as a diagnostic tool but also to track apparatus failure. In this case study the fault and defects that occurred in 400kV/220kV/132kV/66kV Sub Station can be found by DGA.

Keywords: Power Transformer, Dissolved Gas Analysis,

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1. INTRODUCTION

A power transformer is one of the most important and costly devices in electrical systems. Its importance is attributed directly to the continuity of power supply, since its loss through failure or defect means a supply stoppage. This is a large piece of equipment whose substitution is expensive and involves a lengthy process [11]. Power transformers, which are often the most valuable asset in a substation or plant, are indispensable components of high-voltage equipment for power generation plants, transmission systems and large industrial plants [15]. Unexpected failures cause major disturbances to operating systems, resulting in unscheduled outages and power delivery problems. Such failures can be the result of poor maintenance, poor operation, poor protection, undetected faults, or even severe lightning or short circuits. Power transformer failure could result in huge economic loss and unplanned outage of the power system, which may affect a large number of industries and commercial customers also Transformer failure will result in great loss in electrical system. Hence, a well establish maintenance should be conducted [10]

2. FAILURES ANALYSIS

A typical power transformer has a life expectancy of more than 30 years. During this time it is obvious that such a device has several failures, thus needing maintenance to ensure that the expectancy is fulfilled. Because transformer failures are responsible for a very high amount of costs**,** some of the most important causes of failures in power transformers are shown in table

Table 2.1 Failure Mode of Transformer

Description	Failures		Duration	
	No	%	TTF	ATF
Periodical Test	48	12	80:39:00	1:40:49
Services	56	14	88:16:00	1:34:34
Protective Operation	206	50	264:22:00	1:17:00
Insulation Problems	16	04	107:40:00	6:43:45
Others	86	21	113:23:00	1:19:06
Total	412	100	654:20:00	-

Results of Table 2.1 show that protective operation is the highest failure mode, but average times of the fault is the lowest, due to their causes are temporary and are removed after a little time. Further, in Fig.1.1, the percentage of any type of failures is shown.
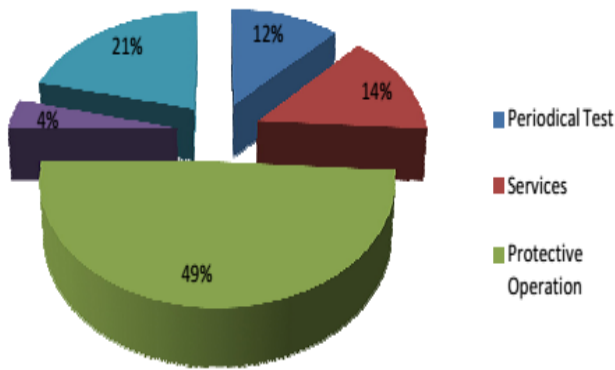
Fig 2.1 The persentage of Failures

In other hand insulation problems are not too much but they have the highest average time of faults. The 5th group is consists of development interruption, bushing faults, tap changer faults, operator failures, lightning, unknown operation errors and etc. The most number of faults of this group are related to Tap Changer failures The main causes of the Tap changers failures start from sparking and erosion of the Tap Changer contacts. Moving parts malfunctioning can also lead to a failure. Eroded contacts produce sparking and sticking. In off -load Tap Changers long period without operation, leads to a corrosion and sludge build up which causes jamming of the moving parts and consequently, a failure of the Tap Changer. Therefore maintenance and periodical test and services can be reduced this type of failures.

3. DISSOLVED GAS ANALYSIS

Gases are formed in oil in the transformer due to natural aging and at much greater rate as a result of faults and incipient faults [1] [12]. The type and severity of a fault may often be inferred from the composition of the gases and the rate at which they are formed. In the case of an incipient fault, the gases formed remain partly dissolved in the oil and only in special cases will free gases be formed. Periodical sampling of oil from transformer and analysis of the dissolved gases assist in the detection of faults at an early stage of development and may enable serious future damage to transformer to be prevented [2] [9].

The gases involved are hydrogen, some hydrocarbons, carbon oxides and atmospheric gases. Some of each of these gases will be formed during normal operation and these amounts are classified as norm [3]. Fault conditions produce gases in higher quantity and in different proportions which vary from the norm, the type and energy of the fault altering the carbon to hydrogen ratio of oil molecules in specifically related ways and producing variation in the carbon oxide ratios when solid insulation is involved [8].

DGA was the first most effective diagnostic test, which was applied to transformers in service for condition monitoring [10]. Gases dissolved in oil are analyzed by gas Chromatography. The technique helps in detecting incipient faults developing in transformers. DGA is supplemented by other tests to confirm diagnosis [4]. Partial lists of fault gases that can be found within a unit are shown in the following three groups:

Fig 3.1: Gases Presented in Transformer Oil

The major (minor) fault gases can be categorized as follows in Table 3.1 and Interpretation of rise in gas concentration in Table 3.2 by the type of material that is involved and the type of fault present [5]: In this table characterization of various fault gases has been done and the major/minor faults occurring due to presence of gases have been shown [18]. If hydrogen traces found in oil then it resembles corona [14]

Table 3.1 Major/minor fault gases characterization

Corona	
Oil	H_2
Cellulose	H_2 ,CO, CO_2
Pyrolysis	
Oil	
Low temperature	CH_4, C_2H_6
High temperature	C_2H_4, H_2 (CH_4,C_2H_6)
Cellulose	
Low temperature	CO_2(CO)
High temperature	CO (CO_2
Arcing	**H_2, C_2 H_2, (CH_4, C_2H_6, C_2H_4**

Table 3.2 Interpretation of rise in gas concentration:

Rise in Gas Concentration	Interpretation
Nil or not appreciable	Normal Aging

H_2	Corona, Partial Discharge
CH_4 & C_2H_6	Thermal fault of low temperature upto 300® C
C_2H_4 With or Without CH_4, C_2H_6, H_2	Thermal fault of 300® C to 700® C or above
C_2H_2 with or Without H_2 C_2H_4 and CH_4	Arc or Flashover

The main drawbacks [6] of this conventional method are unable to predict the fault of a particular transformer owing to the lack of expert knowledge in them.

4. CASE STUDY DISSOLVED GAS ANALYSIS:

400KV/220KV/132KV/66KV S/S

The case study include on the measurement of gas content in transformer oil using Dissolved Gas Analysis. The case study carried out 400 KV Power Transformer, the rating of power transformer is given bellow:
The details of the transformer are as under: -
a. Rating: 12.5/16 MVA, 66/11 kV
b. Sr.no. 2800061017
c. Make: NGEF
d. Date of Commissioning: 17-07-2003
e. Date of last dehydration of Oil: 2003
The DGA testing results for the above mentioned Power Transformer are shown in table5.1 given bellow

Table 4.1 DGA Testing Result

S.N	Gas	Quantity detected in ppm Dated:10-10-2007	Dated: 10-10-2009	Dated: 08-10-2011	Dated: 30-07-2013
1	Methane	65	12	14	14
2	Ethane	17	10	11	11
3	Ethylene	50	20	18	18
4	Acetylene	ND	ND	ND	ND
5	Carbon dioxide	350	765	770	770
6	Hydrogen	25	ND	ND	ND
7	TGC, per 100 ml of oil.	12.15 ml	11.85 ml	11.90 ml	11.90 ml

Methane trends shows events of sparking and Ethane, carbon dioxide content is showing local & severe overheating respectively. However, other gases found within permissible limits. Periodic testing and regular DGA is recommended for the Power Transformer, so that proper monitoring can be done to enhance the life of the Power Transformer. Further, for the 4 years the DGA Trend for the transformer is plotted in the graph shown in Fig 4.1
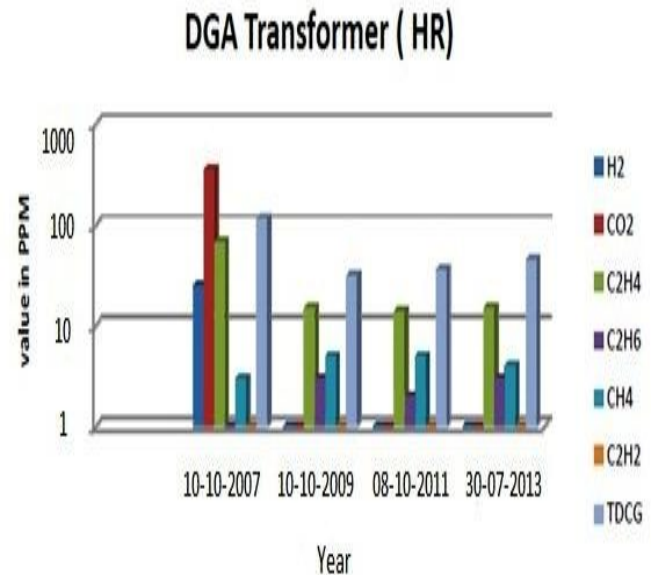

Fig 4.1 Yearly Graph Plot for DGA Result

Oil condition of the transformer is analyzed on the basis of DGA results. It is also seen that by dehydration of oil its BDV increases as well as the traces of various key gases also.

5. CONCLUSIONS

Dissolved Gas Analysis gives a good basis for a monitoring system as it can give a general picture of transformer health. Other parameters can be correlated with DGA to provide the user with detailed information about the condition of a transformer. From this work, the critical components can be carefully maintained. The known causes of failure can help to improve the equipment reliability. In this paper test results of DGA has been discussed and investigated and an attempt is made to find out the cause of fault and its preventive action. It has been found that proper and scheduled monitoring leads to enhanced life of Power Transformer and techniques like dehydration plays an important role in boosting up the condition of Transformer Oil as well the transformer life. However, still some advanced condition monitoring techniques like Partial discharge measurement, Spectrophotometer and SFRA etc. are not yet adaptive by the utilities and thus awareness and training on these issues is required for the betterment of the system

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