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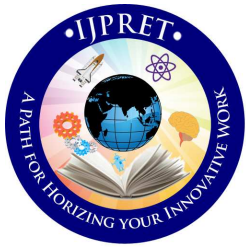

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THE EFFECT OF FRAME LEAKAGE ON PERFORMANCE OF INTERCONNECTING TRANSFORMER, MONITORING BY DGA CASE STUDY

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Abstract

An Interconnecting Transformer (ICT) of rating 400/220/33kV, 3*167 MVA consisting of three number of single phase units each of capacity 167 MVA was commissioned to overcome constraint of over-loading of existing 2*315 MVA three phase units and improving redundancy. During pre-commissioning testing in respect of R-phase unit and Y-Phase unit, frame to tank insulation resistance was found to be zero. After commissioning of the new ICT, two methods of DGA were used for detection of fault gases. The unit of Y-Phase failed on 05.05.2011. The matter was investigated by using Gas Chromatography and Photo Acoustic Spectroscopy methods of dissolved gas analysis. Increasing trend of Acetylene was found using Photo acoustic spectroscopy. To avoid similar failure in future, efforts are taken in this paper to suggest incorporation of frame leakage protection to monitor and so to control such troubles. In this paper , an effort has been made to analyze a specific frame leakage event in case of the ICT, examine its undesirable consequences and so a possible remedy – an innovative protection scheme - to avoid failure of ICT due to such type of frame leakages.

I. INTRODUCTION

At 400 KV Waluj sub-station 2*315 MVA BHEL make ICTs were commissioned in 1999. In due course, development of MIDC area in Waluj and Chikalthana, along with increased demand in residential, commercial and Industrial consumers in the area fed by the Sub Station, led to the rise in demand and overloading of the 2*315 MVA ICTs. In Rabbi Season, in addition to planned load-shedding, 200MW distressed load-shedding became an unpleasant necessity to maintain load profile. To overcome this constraint, 3*167 MVA ICT was erected and all necessary pre commissioning tests were carried out and compared with manufacturer's test results and found in order except magnetic circuit test [1]. Insulation resistance between frame and tank was found to be zero for R and Y-Phase units. However, for B-ph unit it was found to be 50 KMΩ. The experts had expressed their serious concern regarding frame to tank continuity in respect of R and Y-Ph units and the matter was taken up with manufacturer. Manufacturer had assured that "Frame to tank continuity for R and Y-Ph Unit will not affect the performance of ICT and ICT may be commissioned at the risk and cost of manufacturer". ICT was commissioned on 24.10.2010 with fear of developing some incipient fault inside the ICT.

As per "Central Board of Irrigation and Power"[1] Transformer manual clause number 2.4, "after assembly each core shall be pressure tested for 1 minute at 2000V AC between all bolts side plates and structural still work".

- No conducting loops must be formed; otherwise circulating current will result in creating increased losses and / or localized overheating.
- In order to comply with the above requirement so as to avoid circulating current, the core and frame need to be effectively insulated from tank and each other.

However for R and Y-Ph Units for the case under consideration, frame to tank continuity resulted in forming a conducting loop and thereby gave rise to circulating current which ultimately led to localized overheating and development of incipient fault.

As the ICT was commissioned with the above mentioned 'frame to tank continuity' – which is undesirable –it led to failure of Y-Ph unit mainly due to frame leakage current.

II. PROPOSAL

After commissioning of ICT, it was decided to monitor health of ICT by a traditional effective tool i.e. Dissolved Gas Analysis [2]. Manufacturer of ICT has its own developed laboratory for DGA and MSETCL outsourced services to local agency for DGA by using Solid Gas Chromatography technique. Results of DGA indicated that Fault Gases such as Acetylene, Ethane, Ethylene, and Methane were absent i.e. BDL (below detection level); however Y-Ph unit failed on Dt.05/05/2011.Quantum of Acetylene measured before failure was BDL (below detection level) ppm and after failure, it was 1082 ppm. After failure, tank to core and frame to core copper strips (12.5 mm thick) were found burnt. Failure photo graphs are shown in figure numbers 2, 3 and 4.

Further it was decided to carry out DGA by 'Transport X'- popularly called as Kelmen Kit- using Photo Acoustic Spectroscopy technique [3] with increased frequency and to cross check it at PGCIL laboratory, Hyderabad where 'Transport X' is used for DGA. 'Transport X' results, in both the cases, confirmed presence of Acetylene and established a rising trend of Acetylene. Graphs of Solid Gas Chromatography results and Transport X results are shown in figures 6, 7, 8, 9, 10 and 11.

It is proposed that "Frame leakage protection" may be incorporated with Transformer which will help in alarming such conditions. Precautionary measures to be taken after receipt of alarm are

a) DGA with increased frequency say monthly to be done
b) DGA by using 'Transport X' kit to be done
c) If fault gases are detected with rising trend, Transformer may be taken out of service for internal inspection and rectification of trouble.

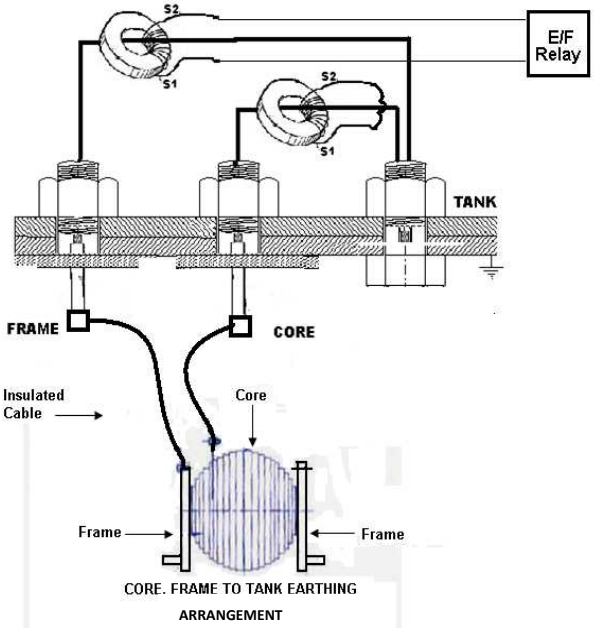

Figure 1: Schematic Diagram of Frame – Core- Tank Interconnections

After installation and commissioning of the proposed frame leakage protection, it is expected that when insulation between frame and tank starts weakening and conducting loops are formed, frame leakage protections should raise alarm to indicate the situation for necessary further action to be initiated to prevent such type of failure in future, refer figure 1.

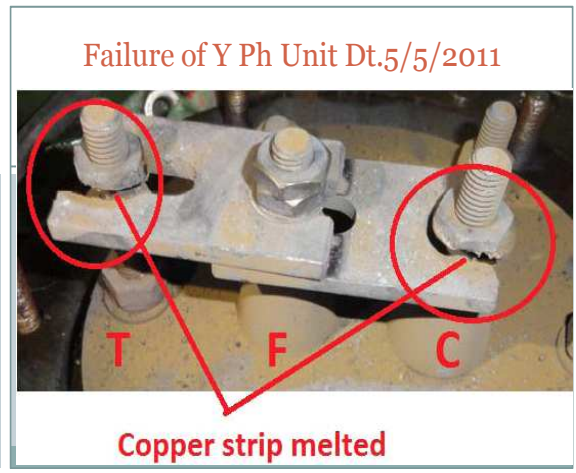

Figure 2: Photograph of tank, core and frame strip connections

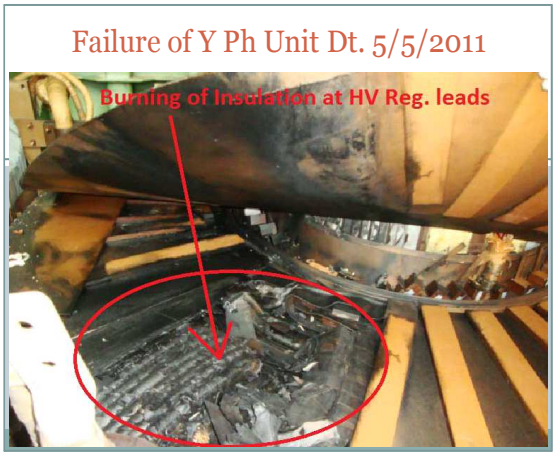

Figure 3: Fault inside the Transformer

Figure 4: The failed winding top layer

III. Analysis Methodology used for DGA:

- By Manufacturer Of ICT And Outsourced Agency Hired By MSETCL Aurangabad Is - "Solid Gas Chromatography"
- In "Transport X" Kit Used By MSETCL And PGCIL Lab At Hyderabad Is -" Photo Acoustic Spectroscopy" [4] In Solid Gas Chromatography:
- Gas Extraction Is Done By Heating Oil (Oil Sample Collected Is Heated To Maximum Temperature As That Of Oil Temperature At The Time Of Sampling), Magnetic Stirring And Application Of Vacuum [5].
- Retention Time Required for Each Gas Is Unique and Directly Proportional to the velocity which is directly proportional to molecular weight of gas molecule. Since retention time is unique for each gas, this 'retention time' parameter is used for identification of gas.
- Area occupied in column by gas is used for quantification [6].

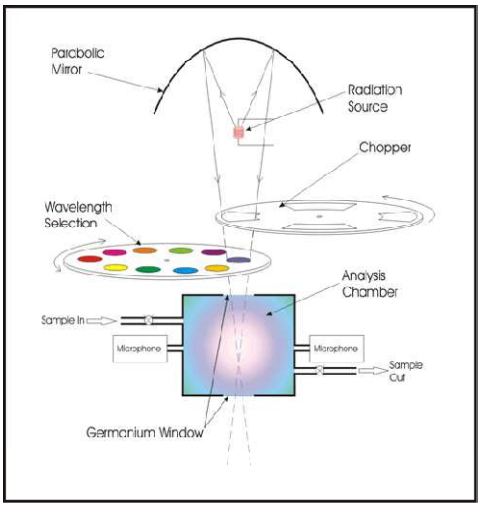

Figure 5: Illustration of a typical multi gas pas spectrophotometer.

RESULTS

The results are as shown in the following figures

Only Chromatography R Phase 3*167 MVA ICTIII				
		All Hydro-Carbons		
Date	C2H4	C2H6	C2H2	CH4
09.11.10	0.2	0.3	0.4	0.5
21.01.11	0.2	0.3	0.4	0.5
07.05.11	0.2	0.3	0.4	0.5
16.02.11	0.2	0.3	0.4	1.1
19.08.11	0.2	0.3	0.4	0.5
29.08.11	0.2	0.3	0.4	0.5
31.08.11	0.2	0.3	0.4	0.5
30.12.11	0.2	0.3	20	0.5
08.06.12	0.2	0.3	0.4	0.5
11.10.12	0.2	0.3	0.4	0.5

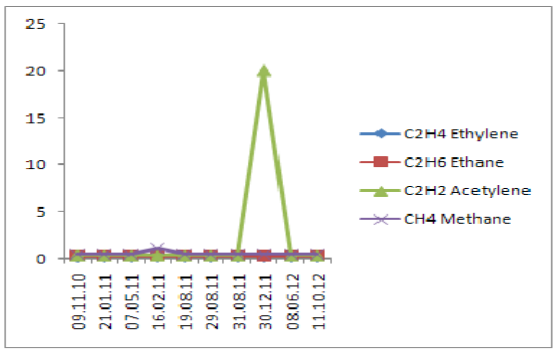

Figure 6: All Hydrocarbons noticed ingas Chromatography

Only Chromatography Y Phase 3*167 MVA ICTIII(Failed Unit)

Date	CO	CO2	C2H2	CH4	C2H4	C2H6
09.11.10	14	168	BDL	BDL	BDL	BDL
21.01.11	29	239	BDL	BDL	BDL	BDL

BDL : Below Detection Level

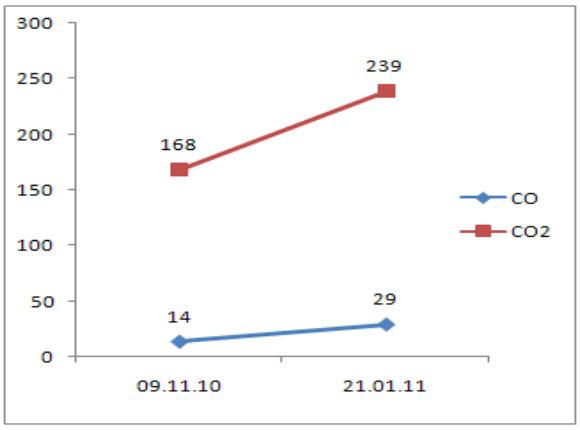

Figure 7: Results of failed unit

Only Chromatography B Phase 3*167 MVA ICTIII

Date	C2H4	C2H6	C2H2	CH4
09.11.10	0.2	0.3	0.4	0.5
21.01.11	0.2	0.3	0.4	0.5
07.05.11	0.2	0.3	0.4	0.5
16.02.11	11	6	1.24	2.3
19.08.11	0.2	0.3	0.4	0.5
29.08.11	0.2	0.3	0.4	0.5
31.08.11	0.2	0.3	0.4	0.5
30.12.11	0.2	0.3	20	0.5
08.06.12	0.2	0.3	0.4	0.5
11.10.12	0.2	0.3	0.4	0.5

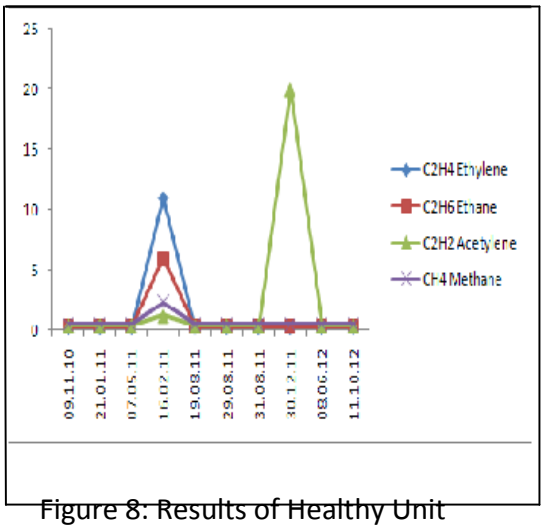

Figure 8: Results of Healthy Unit

Only Chromatography D Phase 3*167 MVA ICTIII			
Date	H2	CO	CO2
09.11 10	0.6	20	225
21.01 11	0.6	30	313
07.05 11	0.6	115	1121
16.02 11	4	21	422.5
19.08 11	6	88	995
29.08 11	16	97	1056
31.08 11	8.9	55	223
30.12 11	10	128	1100
08.06 12	11	185	1521
11.10 12	8	245	2015

Figure 8 (a): Results of healthy unit - other gases

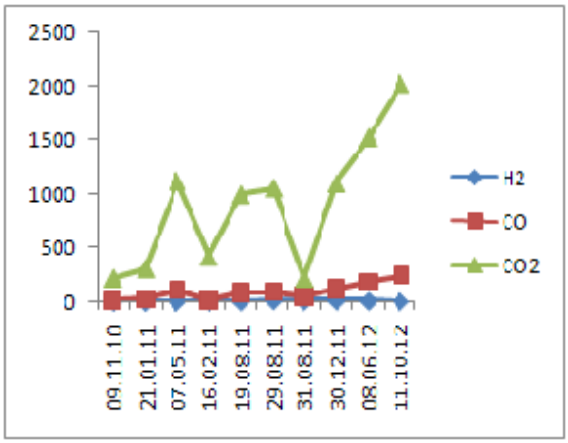

Figure 9: Results of healthy unit - other gases

B. In Photo Acoustic Spectroscopy Technique:

1. Gas extraction is done by magnetic stirrer and application of vacuum during purging
2. Gas identification is done by measuring weave length of sinusoidal acoustic wave produced by each gas when infra red light passes through it
3. Wave length of each gas is unique and is used for identification of gas [4]
4. Quantification is done by converting acoustic signals into electrical signal and by integration through

   electronic circuit for entire test period, figure 5.

So, it appears that, for the case under consideration, the sensitivity level of 'Transport X' is more useful in detection of fault gases.

As per as study of various electrical faults and generation of gases thereofin transformer oil is concerned, the relative quantities of fault gases generated depend upon the nature of electrical fault and the energy available to decompose the oil.

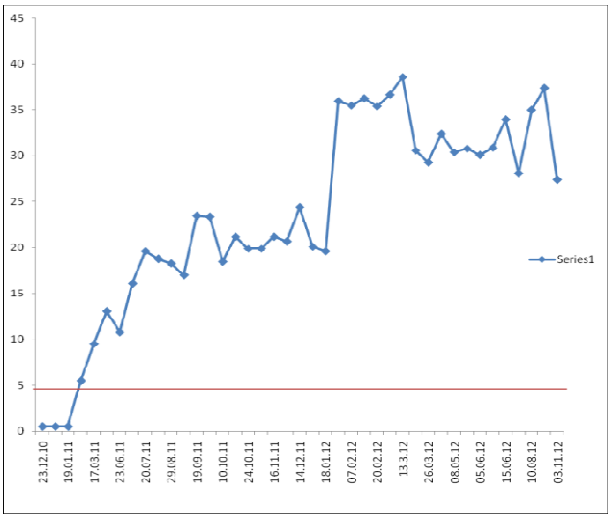

Figure 10: Acetylene growth sick unit

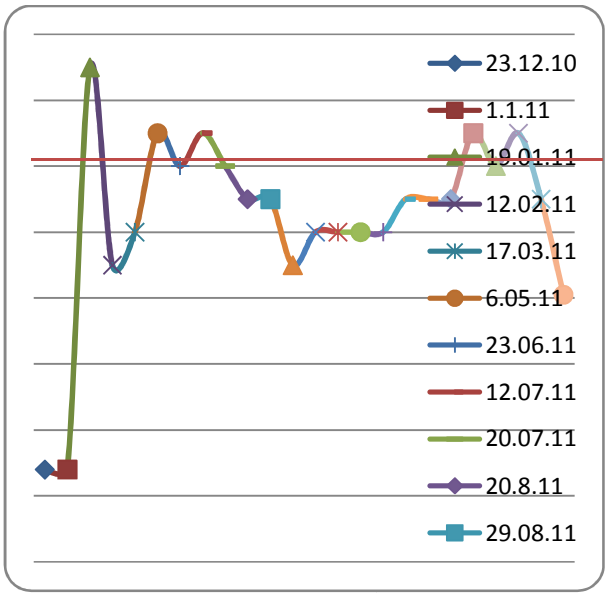

Figure 11: Acetylene trend of healthy Unit

C.Arcing:

Large amounts of Hydrogen (H_2) and Acetylene (C_2H_2)are generated with minor quantities of Ethylene (C_2H_4), CO_2 and CO may also be formed if the fault involves cellulose decomposition [6]. The oil may be carbonized. Key gas for arcing is Acetylene (C_2H_2). In present case of R phase unit, Hydrogen rose from < 5 ppm to 78 ppm and Ethylene C_2H_4 rose from < 1 ppm to 158 ppm and Acetylene C_2H_2 rose from 0.5 ppm to 38.6 ppm, this implies arcing in Transformer tank [7]. Manufacturer was initially reluctant to agree that R- Ph unit is sick, but then with above DGA results, he agreed for removing R-Ph unit for internal inspection and rectification of trouble at the risk and cost of manufacturer.

IV. CONCLUSIONS

1) Frame to tank continuity of Y-Phase unit led to form incipient fault. As result of multiple earthing, fault was developed due to continuous circulating current. It is main cause of failure of Y-Phase unit.
2) Frame to continuity in R-phase unit also led to form incipient fault and rising trend of Acetylene C2H2 and considerable increase in Hydrogen H_2, and Ethylene C_2H_4 indicating ”Arcing” in transformer tank . Though unit is in service, it is sick.

3) As far as this case study is concerned, Photo Acoustic Spectroscopy technique is found more useful for detection of fault gases.
4) During pre-commissioning testing, measurement of IR values should be made compulsory in respect of a) frame to tank b) core to tank c) frame and core hence forth.
5) Necessary amendment in maintenance practice should be made and addition of practice like monitoring Insulation Resistance (a) between Frame and Tank (b) between Core and Tank (c) between Core and Tank- in annual outage- should be done.

Acknowledgment

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