ISSN (Online) 2395-2717

International Journal of Engineering Research in Electrical and Electronic Engineering (IJEREEE)
Vol 4, Issue 3, March 2018

A study of Change in Input Power Factor and Negative Sequence Current Component during Inter-Turn Fault in Dry Type Transformer

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***Abstract*: A power transformer is considered as an influential part of any power system network. The lifespan and performance of transformer mainly depends upon its load parameters. All industries necessitate reduction in cost of operation and maintenance of its equipment. A lot of techniques have been studied and developed concerning incipient fault detection in oil immersed transformer and dry type transformer for accomplishing its cost effective goals. From the analysis, inter turn faults has resulted in 70-75% transformer failures. Therefore, it becomes crucial to exterminate this fault at an initial stage henceforth saving transformer from severe faults, reducing outage time and loss of capital. In this present work a physical model of 10 KVA, 6600/550 Volt transformer is simulated in a power system using MATLAB/SIMULINK software. The experiment is performed at different percentages of inter-turn fault that is 1%, 3%, 5% and 10% on the secondary side of the multi-winding transformer and the change in power factor and negative sequence component of current is tabulated for corresponding fault. The present work is found beneficial in incipient fault detection in underground mines where only air cooled or dry type transformer is present and Buchholz Relay is absent to sense any emerging fault in the transformer.**

***Keywords*: Incipient fault, Power Transformer, Multi-winding Transformer, Negative Sequence Current, Inter-turn fault.**

I. INTRODUCTION

In this modern fast growing world, demand of electrical power supply is increasing day by day from user to user end. And in todays' competitive environment industries and engineers are working together to meet the demand efficiently and economically. Therefore, continuous monitoring of equipment is necessary. Industry has shifted from time based monitoring system to the condition based monitoring in order to reduce the cost of maintenance and operation, reduce the number of outages, reduce revenue loss, reduce production cost, increase reliability of the system.

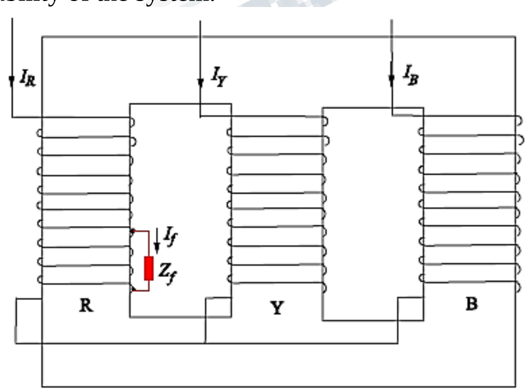

Fig. 1 Inter-turn Fault Schematic Diagram

Power transformer is an integral part of any power system network. Health of power transformer plays a vital role in the reliability of power system network. Several methods have been developed for online monitoring of oil immersed as well as dry power transformer. Bajrachari (2009) in his paper [1] stated that fast power electronic device is one of the reason of insulation failure. Also Bartley (2003) study shows that cost involve in the maintenance of insulation failure of the transformer is high. According to survey conducted it is found that main cause (around 70%) of failure of transformer is inter-turn fault and main cause of inter-turn fault is insulation failure [2]. Therefore, it demands detection of inter-turn fault at primitive stage otherwise this initial fault cause's localized heating and may further lead to more severe fault which will demand capital intensive maintenance and more outage time. A number of methods have been developed regarding online monitoring of power transformer including Dissolved Gas Analysis (DGA), thermal analysis, moisture analysis, acoustic analysis etc. [3]- [5]. but these methods are either expensive or less reliable. Also these methods are applicable for oil immersed transformer. After that wavelet and artificial neural network is introduced but these methods are complex and require large memory for its execution. In [8] negative sequence current component method uses symmetric current component technique is introduced which can be applicable for oil immersed as well dry type transformer. For small fault like 1% to 3% inter-turn fault the magnitude of negative sequence current component is significant but small.

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In this paper a multi-winding 10 KVA 6600/550 volt having 200 turns on secondary, dry type transformer is simulated in a power system using MATLAB/SIMULINK and input power factor and negative sequence current component is extracted and studied for full load, 75% of load having power factor 0.707lag and 0.9 lag with different inter-turn fault condition such as 1%, 3%, 5% and 10%.

II. NETWORK UNDER STUDY

The system represented in fig. 2 comprises of simple network of a practical voltage source, 3-phase transformer and a load. Source having 6600volt phase voltage and internal resistance and inductance of 0.89 ohm and16.58 mH respectively is connected to a 10KVA transformer of impedance (0.005+j0.05) pu on their own KVA rating is feeding power to a lagging load. Load used for study is represented in table1 KVA 6600/550volt transformer have per unit impedance.

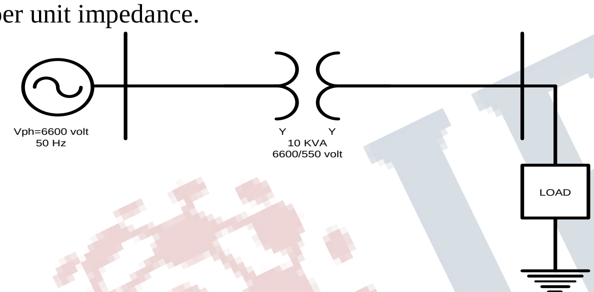

Fig. 2 Single line diagram of system under study

Table 1 Different loads under consideration.

S.No.	LOAD(in kW)	Power Factor
1	7.07	0.707(lag)
2	5.30	0.707(lag)
3	9.00	0.9(lag)
4	6.75	0.9(lag)

so equivalent number of turns is shorted for respective percentage of fault occurred in the system i.e. 1%,3%,5% and 10% inter-turn fault. A negative sequence analyser is used on the secondary side of the transformer to calculate the magnitude and phase of negative sequence current component which denotes the severity of fault. And phase locked loop circuit along with the memory is used on the primary side of the transformer to determine the power factor angle between the input phase voltage and current for the different fault magnitude and different loading conditions.

III.RESULTS AND DISCUSSIONS

A load of 7.07kW, 0.9pf lag is fed by the transformer and negative sequence component from secondary current is obtained and tabulated in table 2. Similar process is done with other load of 5.3 kW, 0.9pf lag and results obtained are shown in table 3.

Table 2. Results with 7.07 kW 0.7 pf lagging load

S. No.	% OF INTER-TURN FAULT	INPUT POWER FACTOR	PF ANGLE (in degrees)	NEGATIVE SEQUENCE CURRENT
1	0%	0.8819	28.142	0
2	1%	0.7255	43.512	0.05359
3	3%	0.5351	57.679	0.1578
4	5%	0.4415	63.833	0.2582
5	10%	0.3432	69.964	0.4939

Table 3. Results with 5.3 kW 0.7 pf lagging load

S. No.	% OF INTER-TURN FAULT	INPUT POWER FACTOR	PF ANGLE (ø)	NEGATIVE SEQUENCE CURRENT
1	0%	0.8841	27.873	0
2	1%	0.6886	46.504	0.04073
3	3%	0.4893	60.736	0.1199
4	5%	0.4042	66.193	0.1961
5	10%	0.3209	71.319	0.3749

Again load is changed to 9kW and 6.75 kW with 0.9pf lag and the output obtained is represented in table 4 and table 5 respectively.

Table 4. Results with 9 kW 0.9 pf lagging load

S. No.	% OF INTER-TURN FAULT	INPUT POWER FACTOR	PF ANGLE (ø)	NEGATIVE SEQUENCE CURRENT
1	0%	0.7001	45.588	0
2	1%	0.5598	55.986	0.05369
3	3%	0.4309	64.508	0.1552
4	5%	0.3713	68.239	0.2539
5	10%	0.3079	72.104	0.4862

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Table 5. Results with 6.75 kW 0.9 pf lagging load

S. No.	% OF INTER-TURN FAULT	INPUT POWER FACTOR	PF ANGLE (ø)	NEGATIVE SEQUENCE CURRENT
1	0%	0.696	45.916	0
2	1%	0.5347	57.706	0.04021
3	3%	0.4115	63.192	0.0796
4	5%	0.3482	69.658	0.1937
5	10%	0.2945	72.909	0.3705

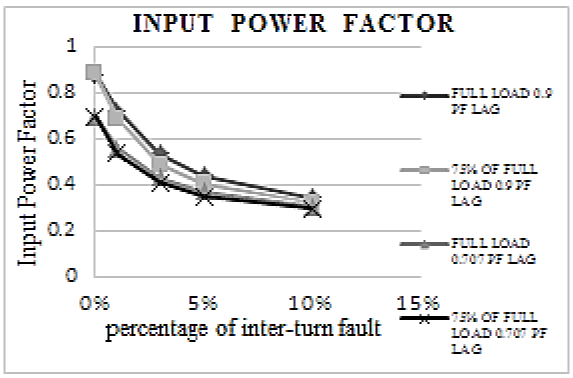

Fig. 2 Comparison of input pf with different loading conditions and different percentage of inter-turn fault

IV. CONCLUSION

The above studies on transformer shows that negative sequence current increases and input power factor decreases with the decrease in the magnitude percentage of inter-turn fault with different loading conditions. As inductance of coil is directly proportional to the square of the number of turns of the coil also for inter-turn fault of less turns, the equivalent inductance decreases rapidly which directly reflects in the power factor. This parameter is easy and simple to extract for monitoring without much involvement of cost and can be very useful in incipient fault detection of dry type transformer generally used in underground mines where Buchholz Relay is unavailable for interception of any incipient fault.

V. ACKNOWLEDGEMENT

The authors are thankful to IIT(ISM) Dhanbad and also express their gratitude towards Prof T.K Chatterjee of Department of Mining Machinery IIT(ISM) Dhanbad for constructive suggestions and important support throughout this work.

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