Modeling And Detection of Turn-To-Turn Fault In Transformer

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Abstract- *Initially it is very difficult to find out internal fault in transformer. These internal faults are hazardous and cause overheating of transformer oil and winding. It consequences as insulation failures because of this uninterrupted power supply can be continued. It is more difficult to detect internal fault in small rating of transformer. Buchholz relay is classical method for detecting this internal fault in transformer but this method is based on generation of gases during fault. To identify the turn-to-turn fault location in power transformer by core flux based technique in which we use some isolated multi turn winding as pursuit loops (search coils) must be wrapped around the transformer center legs to detect the related passing flux. These search coils will not change the structure of transformer. Since going equivalent flux through a transformer center leg in ordinary condition actuates parallel voltages demonstrates the blame occurrence in that stage. Variation in the core flux in the corresponding sensors indicates the faulty phase and the turn to turn fault location on that phase as well. This can be done by some simulation process and experimental tests and obtain result show that the proposed technique successfully detects all TTFs, identify the faulty phase and specifies the faulty region on that related phase.*

I. INTRODUCTION

The power transformer is mostly used & important equipment for the generation and distribution process since it is highly expensive device their black out may bring about expensive and difficult to repair. For every transformer, protections and windings are the most basic component. The main blame that happens in transformer is turn-to-turn blame, which may produce harm in winding on transformer including winding, insulation failure and the blast of transformer in view of overheating of protecting fluid. One of the most important parts of transformer is the insulation system that can be used by electrical, mechanical and thermal stresses and moisture. Failure of insulation system causes breakdown in insulation and creates inter turn faults. Internal turn-to-turn faults are the most dangerous types of faults which is found in the transformer. If turn-to-turn fault has not been detected as earlier as possible it causes more critical faults in the transformer. Such as phase-to-phase or phase-to-ground fault. Therefore, immediate detection of turn-to-turn fault in important to protect the whole electrical system.[1]

There are three methods categorized for turn-to-turn fault detection-

i. Current and voltage components based
ii. Frequency characteristic based
iii. Flux based

Since we use the technique on the basis of measuring the core flux by the search coils (SCs).There are many sensors used for measuring the flux such as

Fluxgate magnetometer
Hall Effect sensor
SC magnetometer

Mostly a short circuit found on few turns of transformer ending will result in savior short circuit in other neighboring turns. Major short circuit current will not appeared across transformer terminal due to high transformation ratio of entire winding and short circuited turns. As experimental results the differential relay used in transformer is not so far effective to found such turn to turn fault. Therefore fast and reliable method for detection of turn to turn fault is difficult work in entire electrical system.[2]

Search coil is more reliable and simple sensor for sensing the flux that detects the faulty conditions in electrical system.

The principle used in the search coil is based on Faraday's law of induction. The voltage is get generated at its leads due to the change in magnetic flux in conductor coil which is proportional to its rate of change of flux. The sensing device is used to show the magnetic flux which is too small as 20fT (2*10^-5 nT) there is no limitations for their sensitivity range .their proper frequency range from 1 Hz to 1 Mhz.[3]

The method used in [4,5]is based on leakage flux .these method is used during turn to turn faults in winding for sensing the leakage flux in these method some sensing device are placed next to HV winding.(it can be proximity sensor)for sensing and measuring leakage flux occurs during TTFs. In this method allowable gap used within sensing device at the HV winding is most important part. as it affects the whole construction of tank and transformer which is necessary to change a design. In case of online problem the circuit used for detection of TTF is get protected from high voltage surge and all not able to found faulty location of abnormal condition at winding.

In [6] Search coil method is presented. The search coil is placed near the HV winding is used to detection of turn to turn fault .In normal condition of search coil, the addition of core flux and particular part of leakage flux are passing through the search coil ,In search coils during TTF there is drop of core flux in faulty location and rise in flux leakage where it results that decreasing in the magnetic flux line that are travel through the search coil, due to these the generated voltage in respective search coil will drop out. These structure has been presented in this paper is for up to 2.5 KVA transformer therefore it is mandatory to provide a insulation layer between the search coil in HV winding which is used for online application where high voltage power transformer get permanently installed .somewhere for small TTF travelling flux cannot be changed which is also enable to change. Therefore the high sensitivity does not get effectively by this method.

II. HARDWARE'S FOR SYSTEM DESIGN

3 phase Transformer
Regulated Power Supply
Microcontroller Atmega328p
Transformer
16*2 LCD Circuit
Temperature Sensor
Vibration Sensor Oil Level Sensor
Oil Quality sensor
GSM Modem
Buzzer

DESIGN OF TRANSFORMER

Design step for Transformer

Step –I Design of Core

Emf Equation
$E=4.44*\Phi m*f*N$
Calculate volt ampere (VA)
(Vs*Is)
Calculate Turns/volts (Te)
From the given table
Calculate flux
$\Phi m = 1/4.44*f*Te$
Consider maximum flux density
$Bm= 0.95 wb/mm^2$
Calculate net area of core
$Ai= \Phi m/Bm$
Gross area of core
Agi= Ai/0.9 (where 0.9 is stacking factor)
$Wd= (Agi)^{1/2}$

Step- II Design of Primary Winding

Calculate current in primary winding
$Ip= VA/Vp*\eta$

Where,
VA =Volt ampere
η = Efficiency and its value is to be considered in between
Calculate area of primary winding conductor
$Ap= Ip/\delta p$ mm2
Where,
δp – Current density of primary winding conductor in A/mm2
From the area diameter of bare conductor is calculated as
$d = (4*Ap)/\pi$ mm
Diameter of insulated conductor is calculated from given table (di)
New Area of primary conductor used
$Ap= (\pi/4)*d^2$
Number of primary turns
Tp= Primary voltage* Turns/volts
$Tp= Vp*Te$
Window space required
$= (Tp*Ap)\ mm^2$

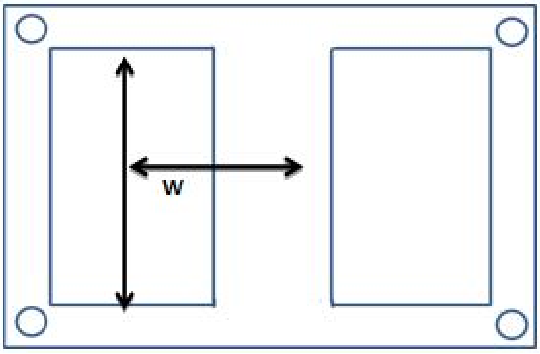
Step- III Design of Secondary winding

Secondary current $I_s$is given
Calculate area of sec. winding conductor
$As= I_s/\delta$ δ= current density
Calculate diameter of bare conductor from area
Calculate diameter of insulated conductor from table below
New Area of primary conductor used
$Ap= (\pi/4)*d^2$
Number of secondary winding turns
T_s= Primary voltage* Turns/volts
$T_s= Vp * Te$

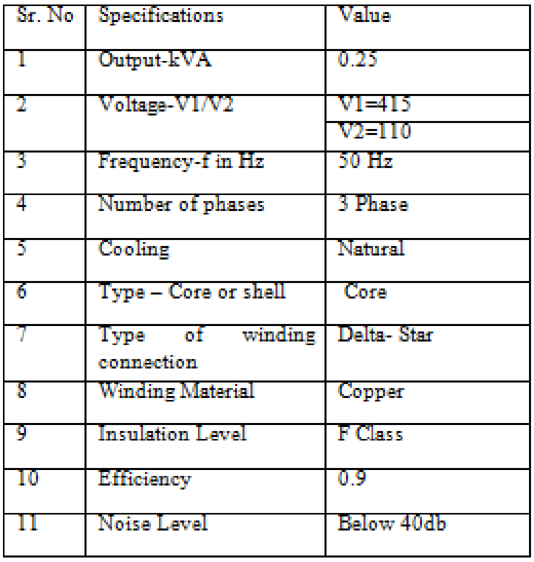
Step IV:- Calculation of core dimension

Height of Winding
H= (turns/layer) * Diameter of conductor

Width of winding
W= number of layer * diameter of conductor



Design Calculation for 3-Phase Transformer



Sr. No	Specifications	Value
1	Output-kVA	0.25
2	Voltage-V1/V2	V1=415 V2=110
3	Frequency-f in Hz	50 Hz
4	Number of phases	3 Phase
5	Cooling	Natural
6	Type – Core or shell	Core
7	Type of winding connection	Delta- Star
8	Winding Material	Copper
9	Insulation Level	F Class
10	Efficiency	0.9
11	Noise Level	Below 40db

III. SPECIFICATION

KVA rating

The output voltage of transformer and output current of transformer is 110V and 2.27 A respectively

Therefore, kVA rating of transformer is given by

$$kVA = V_L I_L 10^{-3}$$
$$kVA = 110 * 2.27 * 10^{-3}$$
$$kVA = 0.25$$

Conductor size

The size of conductor is decided by the current rating of transformer

Primary side voltage (Vs)= 415V
Conductor size of primary side
Primary side current

$$Ip = \frac{kVA * 10^3}{\sqrt{3} * Vs}$$
$$Ip = 0.347A$$

Iph= $Ip/\sqrt{3}$
Iph=0.2A
We know that current density is given by

$$\delta = \frac{I}{A}$$

Where,
I= Current in ampere
A= cross sectional area of conductor
(Note: The value of current density for copper is 3 A/mm$^{2)}$
Therefore,

$$\delta_p = \frac{I_P}{A_D}$$
$$A_P = \frac{I_P}{\delta_p}$$

$$A_P = 0.0669\ mm^2$$

But area of conductor is given by,

$$A = \pi \frac{d^2}{4}$$
$$d_s = \sqrt{\frac{4 * A}{\pi}}$$

$$d_s = 0.2946\ mm$$

SWG of conductor =31

Conductor size of Secondary side

$$Is = 1.31\ A$$

We know that current density is given by

$$\delta_s = \frac{I_s}{A_s}$$
$$A_s = \frac{I_s}{\delta_s}$$
$$A_s = 0.437\ mm^2$$

But area of conductor is given by,

$$A = \pi \frac{d^2}{4}$$

$$d_s = \sqrt{\frac{4 * A}{\pi}}$$

$$d_s = 0.71\ mm$$

SWG of conductor =22

Cross sectional area of core

Core cross area can be calculated as

$$A = \frac{K\sqrt{Q}}{4.44 * Bm * f}$$

$$A = 1541.01mm^2$$

$$A = 1541mm^2$$

Turns per volt

Turns per volt is given by

$$T_e = \frac{1}{4.44 * \varnothing_m * f}$$

But we know, Flux density

$$B_m = \frac{\varnothing_m}{A}$$

Where,

Bm = Maximum flux density in Wb/m^2

$\varnothing_m$ = maximum flux in Wb

A = Cross section area of core

Note: The value of flux density taken in between 1 to 1.6 Wb/m^2 In this case selected as 0.95 Wb/m^2

Therefore,

$$A = \varnothing_m\ in\ m^2$$

$$T_e = \frac{1}{4.44 * B_m * A * f}$$

$$T_e = 3.07$$

Primary turns

$$Primary\ no.of\ turns\ \ T_p = V_p * T_e$$

$$T_p = 1276.93$$

$$T_p \cong 1277$$

Secondary turns

$$Secondary\ no.of\ turns\ \ T_s = V_s * T_e$$

$$T_s \cong 195$$

Core dimensions

There are mainly two types of dimensions:

1) Height of window
2) Width of window

1) Height of window

$$H_w = \left(\frac{turns}{layer}\right) * diameter \quad mm \qquad H_w = \quad 63\ mm$$

Hw=63mm+(10% of tolerance of 63)+(gap mm)=75

2) Width of window

Ws=width of secondary winding=D*L=0.71*3=2.133mm

Wp=width of primary winding=D*L=0.2946*6=1.76mm

Ti=thickness of insulation=4mm

Tb=thickness of bobbin=3mm

$$W_w = 2(Ws_{+Wp+Ti+Tb}) \quad mm$$

$$W_w = 35 \quad mm$$

Drawbacks of Conventional method used for Turn-to-Turn fault detection-

By using Buchholz relay-

The faults like failure of insulation turns, core breakdown or heating of core , the fault is accompanied by production of excess heat. This excess heat decomposes the transformer insulating oil which result in production of gas.

The main drawback of the Buchholz relay is that, it can be used only in oil immersed transformers with the conservators.

The Buchholz relay detects only faults below oil leveling of the transformer.

Buchholz relay produces the trip signal during earthquake.

If fault occurs the relay consumes more time to detect a fault.

This method is not economical as compared to surge coil based method.

IV. ADVANTAGES

- This project Avoids electrical accidents to line man

- This is the best way to prevent unauthorized access of load or line.
- Installation of this project is simple and easy.
- This project is easily compactable with any transmission & distribution network as well as any important loads.

V. FUTURE SCOPE

- Buchholz relay will be removed
- Time of fault detection will be reduced

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