INVESTIGATION OF CAST RESIN TRANSFORMER MANUFACTURING IN AM SGB SDN BHD

VALLIAMMAI A/P S.PALANIAPPAN

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Faculty of Electrical & Electronics Engineering

Universiti Malaysia Pahang

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ABSTRAK

Tesis ini adalah satu penyelidikan yang berdasarkan jenis transformer yang akan datang yang merupakan sebuah transformer jenis kering atau lebih dikenali sebagai transformer Cast Resin. Kajian ini memfokus kepada proses pembuatan menghasilkan transformer Cast Resin serta reka bentuk dan kawalan kualiti. Selain itu, kelebihan menggunakan transformer jenis kering ke atas jenis lain akan dianalisis. Sebaliknya, kajian ini memainkan peranan untuk menentukan penyelesaian untuk mengatasi batasan yang dihadapi oleh industri pada masa yang sama menghasilkan gelung voltan tinggi transformer jenis kering. Masalah utama melibatkan pecahan penebat. Kajian ini akan meneroka beberapa teknik penyelesaian masalah dan teknologi untuk mendiagnosis masalah ini.

ABSTRACT

This thesis is a research based on the upcoming type of transformer which is a dry type transformer or commonly known as Cast Resin transformer. The study focuses on the manufacturing process of producing Cast Resin transformer as well as the design and quality control. Moreover the advantages using dry type transformer over the other types will be analyzed. On the other hand, this research plays a role on determining solution to overcome limitations faced by the industry while producing high voltage coil of dry type transformer. The primary problem involve insulation breakdown. The research will explore several troubleshooting techniques and technologies to diagnose this problem.

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LIST OF ABBREAVIATIONS

HV	=	High Voltage
PD	=	Partial Discharge
ID	=	Inner Diameter
OD	=	Outer Diameter
V	=	Volt

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

A transformer is a gadget that transfers electrical energy from one side to another through its sets of windings. The usage of transformer allows changes in voltage and current values, however frequency remains the same. The energy is transferred by mutual induction caused by a changing electromagnetic field [1]. It consist of two conducting coils which include primary winding and secondary winding. Primary and secondary windings consist of copper or aluminium conductors wound in coil around an iron core. The number of turns in each coil determines the voltage change in he transformer. Primary winding receives the energy which is known as the input while the secondary winding discharges the energy which is the output. Transformers either play a role to step up the voltage or step down the voltage [2]. Most recent type of transformer that is available in the current market will be dry type transformer or commonly known as Cast Resin transformer.

Dry type transformer or more commonly known as Cast Resin transformer is a transformer of which the magnetic circuit and windings are not immersed in insulating oil but used air as insulating agent. The high voltage (HV) coils consist of windings encased in epoxy resin through casting process. This produces a casted HV coil. The low voltage coil is wounded with copper foils along with interleaved fibre glass fabric. This further enhances dynamic stability under short circuit conditions. Dry type transformers are produced only by one company in Malaysia which is Arab Malaysia Starkstrom Gerätebau SDN BHD (AM SGB SDN BHD). AM SGB's manufacturing range of Cast Resin transformer is up to 5000kVa. The transformers produced are three phase transformers [3].

Cast resin transformer outrages other types of transformers due to advantageous properties. The resin used in casting process is made in function with environment and insulation class. The resin makes the transformer fire resistant. The arrangement of the high voltage winding and the void-free casting under vacuum with resin avoids partial discharges, resulting in an impulse lightning-proof design. So this makes Cast Resin transformer is suitable for indoor installation at factories and commercial buildings due to low risk of fire and pollution hazard. Besides that, the HV and LV form of winding reduces additional losses which are an ideal property. Generally dry type transformers require no coolants, with high short time overload capability, totally increased performance and easy installation possibilities. Most importantly its maintenance free as no oil is filled as well as does not require oil spillage containment infrastructure.

However Cast Resin transformers are meant for indoor applications only. Moreover, the physical size is large. Lastly, the initial purchase cost is quite expensive so this type of transformer is not widely used over here in Malaysia. The market of Cast Resin transformer is slowly growing due to purchasing power as well technology transition from Germany.

The manufacturing process of High Voltage (HV) coil of Cast Resin Transformer is shown in the form of flow chart as Figure 1.1[3]:-

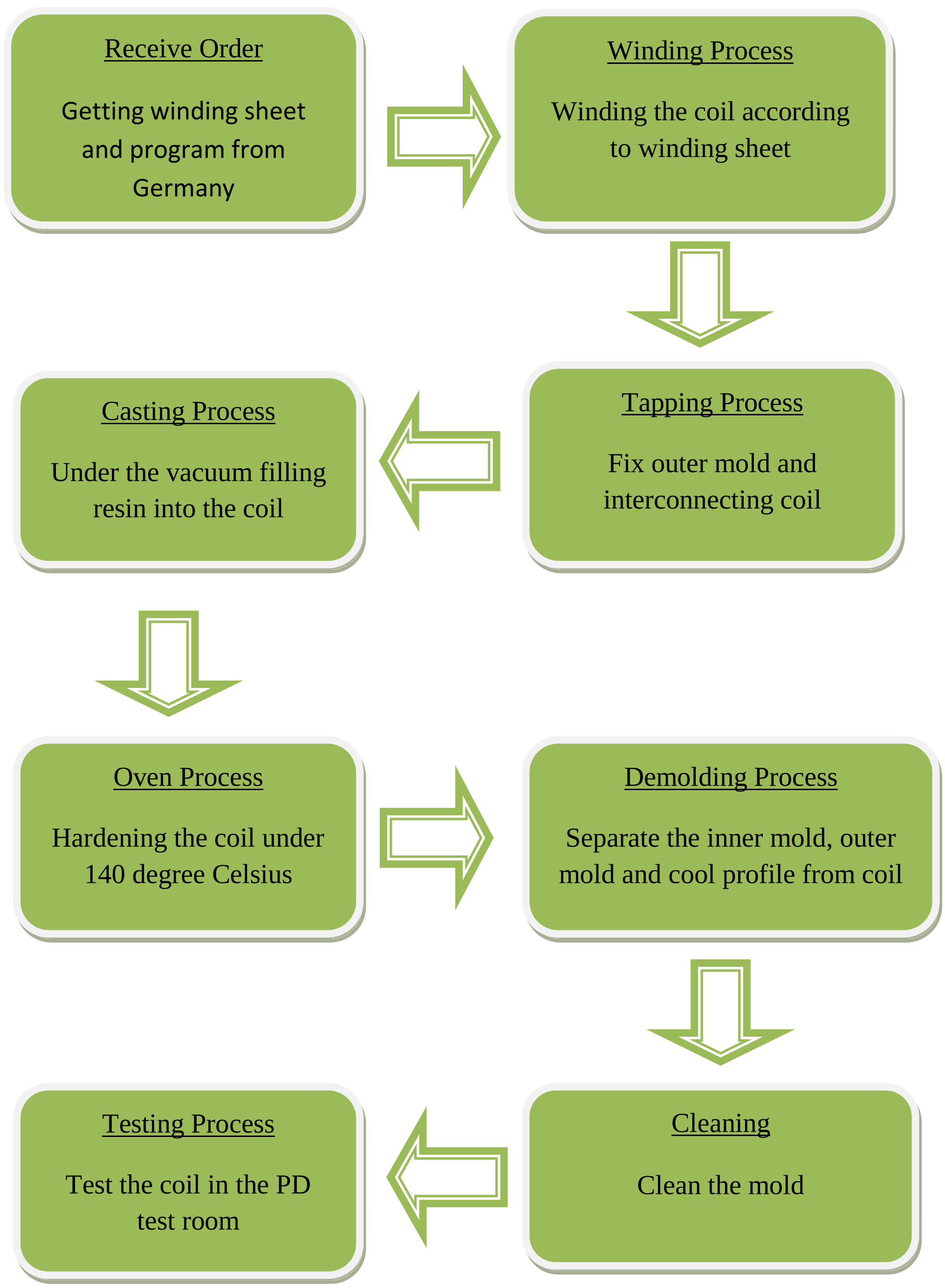
Receive Order
Getting winding sheet and program from Germany
Winding Process
Winding the coil according to winding sheet
Tapping Process
Fix outer mold and interconnecting coil
Casting Process
Under the vacuum filling resin into the coil
Oven Process
Hardening the coil under 140 degree Celsius
Demolding Process
Separate the inner mold, outer mold and cool profile from coil
Cleaning
Clean the mold
Testing Process
Test the coil in the PD test room

Figure 1.1

1.2 Problem Statement

After manufacturing the high voltage coil, Partial Discharge test is carried out. This test is to make sure the coil is free from spark formation due to air gaps. If this test fails the transformer is considered defective. The PD level usually agreed on between manufacturer and customer and varies in between 5pC and 20pC. In AM SGB SDN BHD, failed coils develop cracks and voids which contributed to partial discharge and reduced the reliability of the transformer. These cracks and voids are classified as insulation damage. Insulation can be influenced by different parameters like electrical, thermal and mechanical stresses. Infrared thermography is not commonly practiced at industries to detect insulation failures in the aspect of thermal.

The problem faced at the production area is shown in Figure 1.2:-

Figure 1.2

1.3 Objectives

The objective of this research paper is to study on the thermal stresses influencing partial discharge behaviour. The next objective is to study the thermal images attained from infrared cameras. This is to identify overheating at the terminations and windings. Finally analyze the thermal pattern obtained from normal transformer as well as faulty transformer so the differences and similarities can be found. To carry out all this objectives normal and faulty transformers of AM SGB SDN BHD will be used.

1.4 Scope of Project

The scope of this project is to study the thermal phenomenon on three phase Cast Resin transformer which resolves failure problems faced at the industry. The transformers used in this research carry the same voltage and power rating value. The test carried out on both the transformers will be the same so the resulting images can be used for comparison and discussion.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Insulation problem is considered a severe problem faced by Cast Resin Transformer. Insulation failure can be detected during routine test according to IEC 60076-1 as this test will verify the faults that may occur. This is usually carried out on fully assembled transformer. On the other hand, Partial Discharge test is carried out after the High Voltage (HV) coil is produced as well as after routine test process which also helps in detecting partial discharges due to voids or cracks. So when a HV coil considered as defect due to PD test failure, the reason behind is still unclear. So through this research thermal factor is tested as may be the factor that forms void or cracks on the HV coil.

The routine test held consists of several types of tests;

1. Separate source test
2. Induced over voltage test
3. Measurement of the no load loss and no load current
4. Measurement of the winding resistance
5. Measurement of the load loss and impedance voltage
6. Measurement of voltage ratio and vector grouping
7. Measurement of the insulation resistance
8. Measurement of PTC’s resistance (auxiliary circuit)

On top of these test, another special test called partial discharge test is performed. Both routine and special test is carried out at AM SGN SDN BHD. This study proposes the usage of infrared thermography as an additional test on the HV coil along with these series of tests.

2.2 SEPARATE SOURCE TEST

This test is important in testing the insulation and clearance of the HV/LV coil to core/earth and HV coil to LV coil by using a single phase test transformer. The test value for HV is 11kV:28kV while for LV is 433kV:3kV. The values used to test are usually higher to check the ability to withstand. This test is carried out for 60 sec and no short circuit between HV to LV and other parts [4].

2.3 INDUCED OVER VOLTAGE TEST

This is to test the insulation between turns of the winding (HV and LV). Three phases line fed to the LV terminals of the transformer. Twice of rated voltage is fed at frequency of 125 Hz (433Vx2=866V –feed on LV side). Duration of this test is 48 seconds and no short circuit between turns [4].

2.4 MEASUREMENT OF THE NO LOAD LOSS AND NO LOAD CURRENT

The transformer is energized with rated voltage, normally feed from the LV side and the no load loss is directly from YOKOGAWA Power analyzer meter. Through this test the result must be guaranteed value. Tolerance for No Load Loss (Po) is +15% [4].

2.5 MEASUREMENT OF THE WINDING RESISTANCE

By using the DC power supply (current is controlled), the phase to phase is measured on HV and LV side. The resistance value is determined by calculating V/I formula. Approximately 10% of the rated current is applied on HV side and 15amp current on LV side [4].

2.6 MEASUREMENT OF THE LOAD LOSS AND THE IMPEDANCE VOLTAGE

The LV side is short circuited; feed on HV side with 50% of the3 rated current. Losses (PL) and impedance (ez) which determined at ambient temperature shall be corrected to temperature 120°C by calculation. The tolerance for Load Loss (PL) is +15% and Impedance voltage (ez) is +/- 10% [4].

2.7 MEASUREMENT OF VOLTAGE RATIO AND VECTOR GROUPING

All connection is connected to ratio measuring device. Ratio value must not exceed the guaranteed ratio value. The tolerance of the ratio is +/- 0.5% on the principal tap [4].

2.8 MEASUREMENT OF THE INSULATION RESISTANCE

Meggar tester is used at 2.5kV DC. The value obtained must be above 1kΩ/V [4].

2.9 MEASUREMENT OF PTC's RESISTANCE

Multimeter/resistant is used. The actual resistance is recorded. No short circuit occurs [4].

2.10 PARTIAL DISCHARGE TEST

The calibration is performed on test circuit. The factor Ku is calculated. The wiring is connected as per test circuit. Voltage is applied at 1.8 of rated voltage for 30 seconds. Then it would be reduced to 1.3 of rated voltage for 3 minutes. The discharge value is recorded in the report during 3 minutes period. Charge is recorded at 90,150 and 210 seconds. The value obtained must be below 10pC [4].

2.11 PARTIAL DISCHARGE MEASUREMENT

For the interpretation the Partial Discharge (PD) inception voltage in step test as a function of temperature first a short description of the physical causes will be given. Generally voids or impurities in the dielectric are supposing for the appearance of partial discharges. Microscopically investigations at glass fibre laminate, which are produced under technical conditions, show a certain count of included air bubbles and capillary cavities along the glass fibre layer. These cavities can already come to existence during the production process of the insulating components. Based on the hardening shrinkage micro voids are formed between the polymer matrix and the filler (here: fibre glass-reinforced laminate) at the cooling of the fused mass. It is possible that these voids later grow up to cavities, which can registered by PD measurements. Furthermore the local mechanical strength value of the dielectric can be exceeded by electrostatic forces in connection with mechanical contraction stresses, which are depending on production and material. For that micro cracks will rise. The contraction stresses are based on the non-reversible reaction shrinkage and different coefficients of thermal expansion between the epoxy resin and the included foreign substances. First of all partial separations and cracks can also be produced between the winding of a coil and the moulding material [5].

2.12 INFRARED THERMOGRAPHY

Infrared (IR) thermographic systems, or IR imagers, offer images that represent surface temperatures, or *thermograms*, by measuring the magnitude of infrared radiation emanating from the surface of an object. Because IR imagers see the radiation naturally emitted by objects, imaging may be carried out in the absence of any additional light source. Modern IR imagers resolve surface temperature differences of 0.1ºC or less. With this high sensitivity, they can evaluate subtle thermal phenomena, which are only exposed in the form of slight temperature gradients. Some applications that employ IR thermography include: inspections for predictive maintenance, non-destructive evaluation of thermal and