

INSULATING MATERIALS USED IN TRANSFORMER

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Abstract :-

The solid insulation materials widely used in the transformer are paper, pressboard, and transformer board, which are formed from the cellulose found in plants. The main concern with using dry paper as an insulating material is that it is very hygroscopic. Insulating papers and pressboards must have high dielectric strength and high tensile strength. However, these materials are gradually degraded due to thermal stress, oxygen, and moisture. Because the tensile strength decreases owing to degradation, the degradation of insulating material may affect the life of transformers. In our laboratory, through accelerated tests using models of oil-impregnated insulating systems, changes in characteristics of insulating cellulose materials have been investigated. These data were compared with data obtained from insulating papers of transformers with long service life. From these investigations, good correlation was found between the amount of gas generated from insulating papers in insulating oil and the retention of tensile strength and of degree of polymerization. Using this correlation, the degree of degradation of insulating papers in transformers may be known from the amount of gas. The average characteristic curves of insulating papers from transformers coincides with the degradation curve of 90 ° C obtained in experiments. And if the life of insulating papers is considered to be equal to the life of transformers, the life of transformers is between 20 and 40 years.

INTRODUCTION

The study of Insulating materials used in transformer are in a three State such as solid, liquid and gaseous. The study of insulating material selection, behaviour and Performance are important aspects to be considered for Designing any electrical instrument, machine or device. A part from conductors, insulator forms the backbone of any electrical system. Though insulators form the backbone, they are also the weakest link in the system. hence, maximum care and attention is needed while choosing insulating materials for a given application so that it gives the desired performance under worst working conditions. This paper addresses the problem of selection criteria, test specifications and material treatment to justify the use of various dielectrics/insulating materials used for insulating high voltage instrument transformers i.e. CTs and PT 's.

Hence we want study the insulating material use transformer. Such as Transformer oil OR Mineral oil, DDP (Diamond Dotted Press Paper), Insulating Kraft / Crepe Paper, Cotton Tape, Electrician Laminated wood, Bakelite, Oil Duct Strip, Unidirectional Binding Tape, Phenolic Paper laminated tube, Electrical Press board, cast Resin, Polyester film etc. These material are used in transformer for insulating the conductor. While in use, insulating materials are subjected to various electrical, mechanical, thermal stresses and partial discharges. Therefore, criteria for selection of these materials is, that, they must withstand these stresses without or with such rate of deterioration such that their performance is not affected throughout the life expectancy of the equipment, which is considered approximately 25-30 years.

Besides, mechanical stress, the dielectric has also to withstand electrical stress during lightning impulse and power frequency voltage applications under wet as well as dry conditions. Partial discharge test is an indicator of presence of air pocket in dielectric , loose electric contact, external corona discharge. This is subject to the condition that the properties of insulating material are in conformance to the Specifications/ requirements. The temperature rise of winding when subjected to continuous thermal current or voltage as applicable to instrument transformer at the rated frequency and current/voltage output determines the class of insulation or dielectric surrounding the winding. Having determined the class of insulation or dielectric, the consideration is based on the mechanical/electromagnetic stress generated in windings and in the dielectrics surrounding it, due to dynamic short time current condition. Mechanical stress may occur during normal handling during manufacture, transportation and erection in case of CT and PT beside.

CONSTRUCTION OF TRANSFORMER

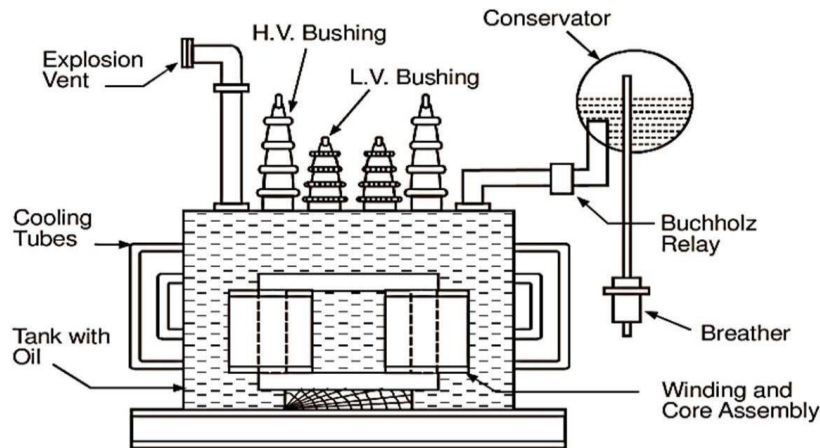


Fig. Construction Diagram of Transformer

Electrical transformer is a static electrical machine which transforms electrical power from one circuit to another circuit, without changing the frequency. Transformer can increase or decrease the voltage with corresponding decrease or increase in current. The basic principle behind working of a transformer is the phenomenon of mutual induction between two windings linked by common magnetic flux. The figure at right shows the simplest form of a transformer. Basically a transformer consists of two inductive coils; primary winding and secondary winding. The coils are electrically separated but magnetically linked to each other. When, primary winding is connected to a source of alternating voltage, alternating magnetic flux is produced around the winding. The core provides magnetic path for the flux, to get linked with the secondary winding. Most of the flux gets linked with the secondary winding which is called as 'useful flux' or main 'flux', and the flux which does not get linked with secondary winding is called as 'leakage flux'. As the flux produced is alternating (the direction of it is continuously changing), EMF gets induced in the secondary winding according to Faraday's law of electromagnetic induction. This emf is called 'mutually induced emf', and the frequency of mutually induced emf is same as that of supplied emf. If the secondary winding is closed circuit, then mutually induced current flows through it, and hence the electrical energy is transferred from one circuit (primary) to another circuit (secondary).

Basically a transformer consists of two inductive windings and a laminated steel core. The coils are insulated from each other as well as from the steel core. A transformer may also consist of a container for winding and core assembly (called as tank), suitable bushings to take our the terminals, oil conservator to provide oil in the transformer tank for cooling purposes etc. The figure at left illustrates the basic construction of a transformer. In all types of transformers, core is constructed by assembling (stacking) laminated sheets of steel, with minimum air-gap between them (to achieve continuous magnetic path). The steel used is having high silicon content and sometimes heat treated, to provide high permeability and low hysteresis loss. Laminated sheets of steel are used to reduce eddy current loss.

INSULATING MATERIAL USE IN TRANSFORMER

A. TRANSFORMER OIL OR MINERAL OIL



Mineral oil has long been the most preferred insulating liquid for power transformer insulation because it has a good pouring point at low temperatures, good thermal cooling capacity, low cost, high efficiency and availability on the transformers market. Petroleum based mineral insulating oil is used in transformer as a dielectric medium as well as a coolant. Transformer oil which belongs to Class A insulation mainly consists of four generic classes of organic compounds, namely, paraffins, naphthenes, aromatics and olefines. Paraffins and naphthenes are saturated hydrocarbons while aromatics and olefines are unsaturated hydrocarbons.

B. DDP (DIAMOND DOTTED PRESS PAPER)

The diamond dotted paper (DDP) is used to reduce the interlayer displacement of transformer winding as well as the temperature rise of transformer oil. The product is suitable for the winding interlayer insulation of amorphous alloy transformers and instrument transformers, etc. Diamond dot transformer insulation paper 12 inch is widely used in the insulation between layers and between turns of oil-immersed power transformers. When used, the coating layer starts to melt at a certain temperature during the coil drying process, resulting in adhesion.

C. INSULATING KRAFT OR CREPE PAPER

Kraft paper is one of the prime insulating materials for covering conductors in transformers. Raman Sigma kraft paper with high purity and mechanical and dielectric strength is perfect for double paper covering (DPC) applications and as layer insulation in transformer designs. Insulation crepe paper has greater surface area which helps to retain more oil and hence lowers the working temperature of the transformer. Compliance to IEC standard. Can also be used as insulation in cables.

D. COTTON TAPE

Cotton tape is used in large quantities for electrical insulation. Cotton is strong since it is a staple fiber with a natural twist. Cotton tape, also referred to as ribbons or tapes webbings, are all considered as woven narrow fabrics if they contain woven selvages and are less than 12 inches. Cloth tape is an adhesive tape made with a cloth backing to make it durable and flexible. The tape is useful for various purposes such as bandages, sealing walls, electrical and plumbing tasks and more. Cloth tapes are easily available in specialty and hardware stores.

E. ELECTRICIAN LAMINATED WOOD

Electrical laminated wood is widely used as insulation and supporting materials in transformers and instrument transformers. It has many virtues such as moderate specific gravity, high mechanical properties, easy vacuum drying, no bad inner-reaction with transformer oil, easy mechanical processing, etc. Densified Wood is a specially engineered product, designed for transformer insulation applications such as coil clamping rings, coil supports. Spacers, lead supports, etc., that require high mechanical strength along with transformer oil absorption.

F. OIL DUCT STRIP

Oil duct strip provides duct for the flow of the cooling oil in layer and strip windings in distribution power transformers. It is manufactured by bonding transformer board sticks onto insulating paper or single-coated diamond dotted paper. Oil duct strip is applied to the coil of the oil type transformer to provide a channel for cooling the transformer oil circulation. The oil duct strip is used to replace the old electrical corrugated board process, which effectively solves the defects of non-standard thickness, collapse and deformation under pressure of electrical corrugated board, and promotes and improves the reliable operation of cooling function. The oil duct strip process is an advanced technology widely used abroad.

G. UNIDIRECTIONAL BINDING TAPE

Unidirectional binding tape has good electrical insulation properties, good flexibility and high tensile strength, which can work continuously at 130°C, 155°C and 200°C according to different heat-resistance classes. It's the most suitable banding material for large motor, transformer, lightning arrester and inductor.

H. PHENOLIC PAPER LAMINATED TUBE

Phenolic paper laminated tube is suitable for insulation structural parts in electrical equipment, and can be used in humid environments and oil transformers. It has high mechanical and dielectric performance, and applicable as insulation structural components for electromechanical/electrical equipment, as well as used under damp environmental conditions and transformer oil.

I. ELECTRICAL PRESSBOARD

This board is made from pure cellulose which is extracted from long fibered coniferous trees. It is first formed into a non woven product without the use of any adhesive or binding agents and then pressed under high pressure to assure its smooth surface & excellent strength. Consistency of fibre layering: The main purpose of insulating pressboard is to stop transmission of electricity across itself. It is used in various forms in a transformer – usually spacers, ducts, trapezoidal or key strips, yoke insulation, phase barrier, footplate, cylinders blocks etc.

J. BAKELITE

Bakelite is suitable for use in transformer oil, in machineries, motors and electric appliances where insulating pieces and parts of high mechanical property are required. Bakelite sheet is a hard, dense material made by applying heat and pressure to layers of paper or glass cloth impregnated with phenolic resin.

K. CAST RESIN

Cast resin dry type transformers are used in high moisture areas. It is because its primary and secondary windings are encapsulated with epoxy resin (non hygroscopic). The encapsulation prevents moisture from penetrating the winding. Available power 25 KVA to 12,500 KVA. Cast Resin Transformers are designed effectively to reduce line cost and line losses and improve the quality and reliability of the electrical supply system.

L. POLYESTER FILM

Polyester reinforced with glass filaments is mainly used as a protective supporting material in oil transformers. Polyester film provides resistance to breakdown, and the introduction of glass filament increases the breaking load. A PET is a polyester or polyethene terephthalate. This is a thermoplastic which is made up of dimethyl terephthalate (DMT) and ethylene glycol. It is crystal clear and offers high performance if you compare it with other polymer firms.

CONCLUSION

- a. Various solid Insulating materials have different breakdown strengths.
- b. Solid Insulating materials once punctured cannot be reused.
- c. Solid Insulating materials has highest dielectric strength.
- d. Liquid dielectrics partially regain their dielectric strength after each breakdown.
- e. Breakdown strength decreases with addition of water impurity

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