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Systematic Steps in Overhauling of a Transformer

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Abstract - *Transformer is an equipment, which converts electrical power from one voltage level to another voltage level without change in the system frequency. The essential components in a transformer are a magnetic core of laminated iron and two windings, the primary and secondary placed around it. The winding that is connected to the source of power is known as the primary winding and the one that is connected to the load is known as the secondary winding.* They are widely used in power systems. With the help of transformers, it is possible to transmit power at an economical transmission voltage and to utilize power at an economic effective voltage. Their maintenance at regular intervals is very important which includes the major overhauling. Overhauling of a large transformer is very complex which will be explained in easy steps in this paper.

***Key Words*:** Transformer, Overhauling, Core, sludge, jetting, Bushing, drying.

1. INTRODUCTION

As compared with most electric apparatus, transformers require relatively little attention. The extent of the inspection and maintenance required will be governed by the size, importance of service continuity, the location on the system, and operating conditions, such as ambient temperature, dirty atmosphere, heavy fogs and water supply (in the case of water-cooled units). Distribution transformers and small power transformers ordinarily require and receive less attention than large transformers, which represent a much greater investment. However, small transformers sometimes supply power to industrial loads where continuity' of service is of the utmost importance. In these cases, a greater degree of attention is justified. A rigid system of inspection and preventive maintenance will ensure long life, trouble-free service and low maintenance cost. Maintenance shall consist of regular inspection, testing and reconditioning, where necessary. The amount of attention and maintenance vary with the service conditions and load cycle of the transformers. Records shall be kept of each transformer giving details of all inspections and testing made and of unusual occurrences. The principal object of maintenance is to maintain the insulation in good condition. Moisture, dirt and excessive heat in contact with oxygen, are the main causes of insulation deterioration and avoidance of these will, in general, keep the insulation in good condition. The limiting factor is the ageing of the insulation and decline in the quality of the insulation during the ageing process due to chemical and physical effects. The decay of the insulation follows the chemical reaction rate.

2. FACTORS AFFECTING LIFE OF A TRANSFORMER

Effect of Moisture -Transformer oil readily absorbs moisture from the air. The effect of water in solution in the oil is to decrease the dielectric strength of the oil as well as of the insulating paper, which absorbs and stores the moisture due to higher affinity of water to paper over oil. All' possible preventive steps should, therefore, be taken to guard against moisture penetration to the inside of the transformers. This will include blocking of all openings for free access of air in storage and frequent reactivation of breathers in service.

Effect of Oxygen - Oxygen may be present inside the transformer due to air remaining in oil, air pockets trapped in the windings, etc. The oxygen reacts on the cellulose of the insulation and the decomposition products of the cellulose lead to the formation of organic acids soluble in oil and sludge which blocks the free circulation of the oil. The adverse 'effect of oxygen, which may be aggravated by catalytic action between hot oil and bare copper, increase the operating temperature.

Effect of Solid Impurities - The dielectric strength of oil is diminished appreciably by minute quantities of solid impurities present in the oil. New transformers may contain particles of insulating materials and other solid *impurities. It is, therefore, a good practice to filter the oil after it has been in service for a short time, especially for the units of higher voltage class.

Effect of Varnishes - Some varnishes particularly of the oxidizing type, enter readily in reaction with transformer oil and precipitate sludge on the windings. Synthetic varnishes having acid-inhibiting properties generally delay the natural formation of acid and sludge in the oil. This should be borne in mind by the maintenance engineer when rewinding and replacing the coils during repairs to transformers.

Effect of Slackness of Windings - Slackness of windings may cause a failure due to repeated movement of coils, which may wear the conductor insulation at some places and lead to an inter-turn failure. The coils may also get displaced under load conditions or momentary short circuit, which may cause electric and magnetic unbalance and produce even greater displacement. It is, therefore, a good practice to lift the core and windings of a transformer and take up any slackness, which may have developed by tightening the tie-rods or- pressure screws where provided for this purpose at the first inspection. In all cases the instructions given by the manufacturers should be followed closely. However, the maintenance schedules given in Tables 1 and 2 are

recommended to serve as a general guidance. Additional maintenance attention should be given where transformers are working under abnormal conditions.

3. PREVENTIVE MAINTENANCE (PM)

Transformers will give trouble free service for a long time if attention is paid to the below mentioned points. Proper record of all the observations and repair and maintenance operations will therefore warn of any impending troubles. A simple preventive maintenance chart of a distribution transformer is shown in table 1.

Table -1: PM Schedule

Inspection Frequency	Items to be Inspected	Remarks
Hourly	i) Ambient temperature ii) Winding temperature iii) Oil temperature iv) Load v) Voltage	Adjust load if temperature is high. Check against rated figures.
Daily	i) Oil level ii) Relief diaphragm iii) Dehydrating breather. iv) Check colour of silica gel, which should be blue.	If low, top up with dry oil. Replace if broken , Check that air passages are free. Change if colour is pink
Quarterly	i) Bushing ii) Oil in Transformer. iii) marshalling box iv) Incomer Circuit. breaker & its control circuit. v)Buchholz relay	Clean or replace. Check Dielectric strength and water content. Check oil level, healthiness of control circuit and other checks based on the visual inspection of transformer and its peripherals.
Half yearly.	i) Check bushes, insulators. ii) Check cable boxes iii) Check gasket. iv) Cooling fans	Replace if damaged. Tighten the bolts evenly. Replace if damaged.
Yearly	i) Check oil for acidity and sludge. ii) Oil filled bushings. iii) Gasket joints. iv) Cable boxes checking.	Filter or replace. Test oil. Tighten the bolts evenly. Replace gaskets if leaking.
	v) Check relays, alarms circuits etc.	Check relays and alarm contacts and their operation.
	vi) Check earth resistance vii) Neutral grounding resistor(NGR) if any.	For methods of lowering earth resistance fill charcoal, salt& water, Insulation resistance values and NGR resistance.
Five yearly	Overall inspection including lifting of core& coils	Wash by hosing down with clean dry oil

Since all are routine checks except overhauling, which will be described in subsequent paragraphs.

4. OVERHAULING

-After taking safety work permit from process, note down the deficiencies of the PTR. Ensure the H.T&L.T side supply breakers are racked out /isolated. Note down the tap switch position and disconnect H.T&L.T cables and neutral connection. L.V bus duct is to be removed up to 1-meter length.

-Disconnect the marshaling box control wires. Take two oil samples from PTR one from top and one from bottom of the tank and test for BDV, water content and acidity. Check the IR values of the transformer.

-Drain the complete oil from tank. Remove the radiator and blind with M.S plate. Disconnect conservator MOG wires, Buchholz relay wires and remove the conservator tank, Buchholz relay, oil temperature sensor. Remove silicagel breather and explosion vent.

-Complete oil is to be filtered (6 circulations min.) and stored in a separate tank to fill after completion of core inspection and maintenance.

-Remove the top cover bolts. Lift the core with the help of crane slowly and keep the core in a M.S tank. Inspect insulation of the windings, winding spacers, core fixing clamps and core.

-Clean the core with hot oil jet (with the help of filtering machine). Inspect thoroughly spacers, insulating cylinders,

bushing end connections, brazing, tap switch and its connections, tie rod, wooden supports etc. and do repairs required of any. A sample photograph of lifted core is shown in Fig. 1 and 2.

Fig. 1 Core assembly out of tank

Fig. 2 one leg of Core assembly

-Keep the core back into the transformer tank. Replace the top cover gasket with new one and close the top cover. Fix blanking plates to radiator pipeline, explosion vent and radiator valves.

-Clean the bushing porcelains and examine them for cracks and chips, Very slight chips may be ignored but any serious damage will require new porcelain, which must be obtained from the manufacturer. It is recommended to have a spare, in stock. In some cases the porcelain only may be changed while in other cases the conducting rod is cemented into the porcelain and the complete bushing requires to be changed. If the bushing is below oil level, the oil should be lowered until it is below the bushing hole.

- Conservators are so arranged that the lower part act as a sump in which any impurities entering the conservator will collect. A valve/plug is fitted at the lowest point of the conservator for draining and sampling. The inside of the conservator should be cleaned or flushed with oil every two to three years. A removable end is generally provided for this purpose. The oil level indicator of magnetic oil Gauge should be kept clean. Generally the oil level is visible through a transparent material. In case of breakage replace the glass by lowering the oil.

-The oil in transformer tends to deteriorate in service, but this tendency can be greatly reduced and even arrested by paying attention to the operation condition and by giving attention to oil itself including filtration.

- The most important practical method of drying out is by circulation of hot oil through a streamline filter, a machine incorporating oil heater and vacuum chamber. If it is preferable to lag or blanket the transformer tank to prevent loss of heat.

-Connect the vacuum pump and create vacuum in the tank and run for few hours. Fill the tank with filtered oil if it is having good values like dielectric strength, acidity, water content etc. Circulate oil by connecting filter m/c, 4 to 6 circulations. Check the IR values of the windings, if the IR values are good, assemble the Buchholz relay, radiators, and conservator and connect all the control wires removed.

-After complete assembling of all the accessories, paint the transformer with 2 coats of red oxide primer and paint with 2 coats of gray colour enamel paint.

-Connect H.V cable, L.V bus duct, L.T connections, neutral C.T connections and all earthing points. Fill oil up to ½ of the level in the conservator. Take conservator & radiator into line and circulate oil through filter m/c for few hours.

-Confirm all oil valves are open, stop the oil filtration. Check IR values of transformer after reaching the temperature equal to ambient air, release air from conservator tank, radiators, Buchholz relay etc.

-Conduct ratio test.

-Conduct core balance test.

-Charge the transformer; check the primary and secondary voltages. Keep the transformer idle charge for 24 hrs. Once again remove the air from Buchholz relay, radiators, and conservator.

-Take the transformer into line. Observe the load at every 1-hour interval for 24 hrs. Record all the measured values in the history register for future reference.

5. CONCLUSION

With regular maintenance, the services from any transformer can be enjoyed years together. Only a little bit of attention and minimum investment on spares and skilled man power gives us a beautiful results in its life time.

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