POWER TRANSFORMER

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INTRODUCTION

- Power transformers are static devices that transfer electrical energy between circuits using electromagnetic induction.
- They operate based on mutual induction in primary and secondary windings.
- They operate at high voltages (above 33 kV) & operates continuously at high efficiency.
- They step up or step down AC voltage levels for efficient power transmission.
- By adjusting voltage, they reduce energy losses in long transmission lines.
- Usually installed at generation stations or substations for voltage level adjustments in bulk power transmission.
- Very expensive and large in size.

CONSTRUCTION & WORKING PRINCIPLE

- The primary structure of a power transformer comprises a magnetic core and windings, all housed within an oil-filled tank to facilitate cooling and insulation.
- The magnetic core is constructed from thin laminated steel sheets, designed to efficiently carry magnetic flux while minimizing eddy current and hysteresis losses.
- The windings, typically made of insulated copper or aluminum conductors, form the primary and secondary circuits of the transformer and are precisely wound around the core limbs.
- The fundamental operating principle relies on mutual induction, where an alternating current in the primary winding generates a time-varying magnetic flux in the core, inducing an electromotive force (EMF) in the secondary winding.
- This induced EMF enables voltage transformation, allowing the transformer to adjust voltage levels according to the system’s specific requirements, ensuring efficient power delivery.

COMPONENTS OF POWER TRANSFORMER

- Core and winding
- Transformer oil
- HT/LT bushing
- Conservator
- Breather and silica gel
- Radiator
- Tap changer
- Buchholz relay

CORE & WINDINGS

- The magnetic core of a power transformer provides a low-reluctance path for the magnetic flux, thereby facilitating efficient energy transfer between primary and secondary windings.
- The core is constructed from thin laminated steel sheets, which significantly reduce eddy current and hysteresis losses, enhancing overall efficiency.
- The primary winding is connected to the input AC voltage source and is responsible for creating the alternating magnetic field in the core.
- The secondary winding is positioned to intercept this alternating flux, inducing the required output voltage for the load.
- Both windings are carefully insulated to withstand high electrical stresses, prevent short circuits, and ensure the safe operation of the transformer.

TANK, CONSERVATOR & BREATHER

- The transformer tank is a metal enclosure that contains the magnetic core and windings, filled with mineral oil or synthetic fluid to provide electrical insulation and cooling.
- The insulating oil acts as a dielectric medium, preventing electrical breakdown, and also as a coolant, transferring heat away from internal components.
- The conservator is a separate chamber mounted above the main tank, allowing for the expansion and contraction of the insulating oil as temperatures change.
- The breather, containing silica gel crystals, is connected to the conservator and removes moisture from the air that enters, preventing the oil from becoming contaminated.
- These components work together to preserve the insulating oil's quality and ensure the safe and efficient operation of the transformer.

BUCHHOLZ RELAY & TAP CHANGER

- Transformers generate heat during operation, and an effective cooling system is essential to prevent overheating and maintain safe operating temperatures.
- The Buchholz relay is a gas-actuated protective device that senses the accumulation of gas produced by internal faults within oil-immersed transformers, providing an early warning or trip signal to prevent damage.
- The tap changer is a key device that adjusts the transformer's voltage ratio, allowing the output voltage to be matched to the load requirements or compensate for voltage fluctuations in the grid.
- On-load tap changers (OLTC) enable voltage adjustments during transformer operation, while off-load tap changers are used when the transformer is de-energized.
- Together, these components ensure safe, efficient, and reliable transformer performance under varying operating conditions.

STAR & DELTA CONNECTIONS

- Star (Y): Neutral available, $\sqrt{3}$ line-to-phase voltage
- Delta (Δ): No neutral, line & phase voltage same
- Use:
  - Star – load side (neutral grounding)
  - Delta – generator side (high current)

NOTE :

- The **humming sound** in transformer is primarily due to a phenomenon known as **magnetostriction** in the transformer core.
- When AC flows through the transformer windings, it creates an alternating magnetic field in the core. This causes the core laminations to expand and contract slightly this mechanical deformation of the core is called **magnetostriction**.

THANK YOU

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