SETHU INSTITUTE OF TECHNOLOGY

15UEE504-Electrical Machine Design

Presented by

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Unit - III

Transformers:

Output Equations – Main Dimensions - KVA output for single and three phase transformers – Window space factor - Overall dimensions – Operating characteristics – Regulation – No load current – Temperature rise in Transformers – Design of Tank - Methods of cooling of Transformers.

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Characteristics of Transformer

Some of the characteristics of a transformer are given below:

- **Variable Voltage**

The input and output voltages of a transformer are variable. A transformer can increase or decrease the supply voltage.

$$V_{out} = V_{in} (N_s/N_p)$$

- **Variable Current**

The current is also a variable quantity in a transformer which can be increased or decreased.

$$I_{out} = I_{in} (N_p/N_s)$$

- **Constant Frequency**

A transformer is a constant frequency operating device. The frequency of the input voltage & the output voltage remains the same.

- **Constant Power**

The power of the transformer remains constant. The power that is supplied to the transformer & the power delivered by the transformer remains the same.

$$P_{in} = P_{out}$$
$$V_{in}\, I_{in} = V_{out}\, I_{out}$$

Applications of Transformer:

A transformer is used in a wide variety of electrical & electronic devices. It is the most common electrical device. Some of its applications are given below:

- It is used for increasing or decreasing the voltage in a circuit.
- It is used for electrically isolating two circuits.
- It is used in AC to DC rectifiers for reducing the High input AC voltages.
- It is used for impedance matching
- Current transformers are used for measurement purposes.
- Distribution transformers are used for reducing the voltage levels for our domestic appliances.
- Voltage stabilizer & regulators

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Cooling Methods of a Transformer:

- No transformer is truly an 'ideal transformer and hence each will incur some losses, most of which get converted into heat.
- If this heat is not dissipated properly, the excess temperature in transformer may cause serious problems like insulation failure.
- It is obvious that transformer needs a cooling system.
- Transformers can be divided in two types as

  (i) Dry type transformers and

  (ii) Oil immersed transformers.

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- **For dry type transformers**
  1. Air Natural (AN)
  2. Air Blast
- **For oil immersed tranformers**
  1. Oil Natural Air Natural (ONAN)
  2. Oil Natural Air Forced (ONAF)
  3. Oil Forced Air Forced (OFAF)
  4. Oil Forced Water Forced (OFWF)

Cooling Methods For Dry Type Transformers:

Air Natural Or Self Air Cooled Transformer

This method of transformer cooling is generally used in small transformers (upto 3 MVA). In this method the transformer is allowed to cool by natural air flow surrounding it.

Air Blast

For transformers rated more than 3 MVA, cooling by natural air method is inadequate. In this method, air is forced on the core and windings with the help of fans or blowers. The air supply must be filtered to prevent the accumulation of dust particles in ventilation ducts. This method can be used for transformers upto 15 MVA.

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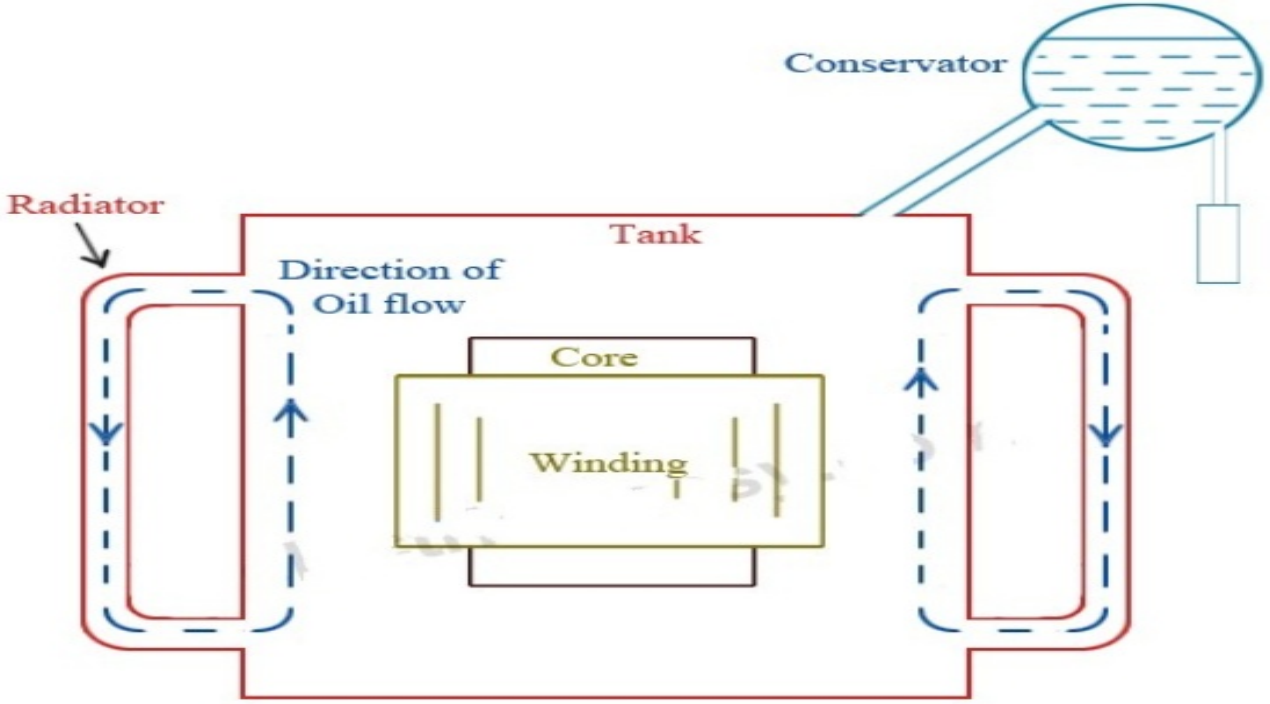
Cooling Methods For Oil Immersed Transformers
Oil Natural Air Natural (ONAN)



Oil Natural Air Natural (ONAN) - Cooling of Transformer

- This method is used for oil immersed transformers. In this method, the heat generated in the core and winding is transferred to the oil.
- According to the principle of convection, the heated oil flows in the upward direction and then in the radiator.
- The vacant place is filled up by cooled oil from the radiator. The heat from the oil will dissipate in the atmosphere due to the natural air flow around the transformer.
- In this way, the oil in transformer keeps circulating due to natural convection and dissipating heat in atmosphere due to natural conduction. This method can be used for transformers upto about 30 MVA.

Oil Natural Air Forced (ONAF)

- The heat dissipation can be improved further by applying forced air on the dissipating surface.
- Forced air provides faster heat dissipation than natural air flow.
- In this method, fans are mounted near the radiator and may be provided with an automatic starting arrangement, which turns on when temperature increases beyond certain value.
- This transformer cooling method is generally used for large transformers upto about 60 MVA

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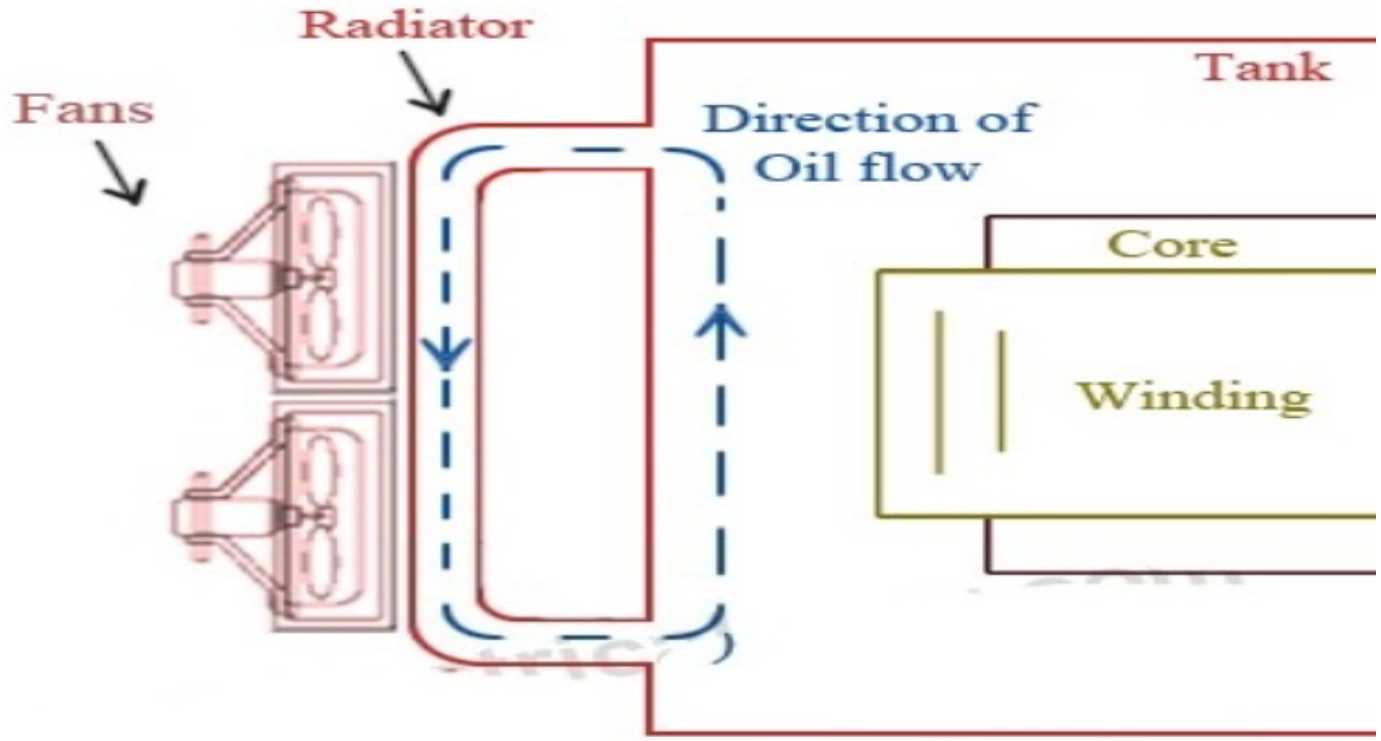

Oil Natural Air Forced (ONAF)
Cooling of Transformer

Oil Forced Air Forced (OFAF)

- In this method, oil is circulated with the help of a pump. The oil circulation is forced through the heat exchangers.
- Then compressed air is forced to flow on the heat exchanger with the help of fans.
- The heat exchangers may be mounted separately from the transformer tank and connected through pipes at top and bottom as shown in the figure.
- This type of cooling is provided for higher rating transformers at substations or power stations.

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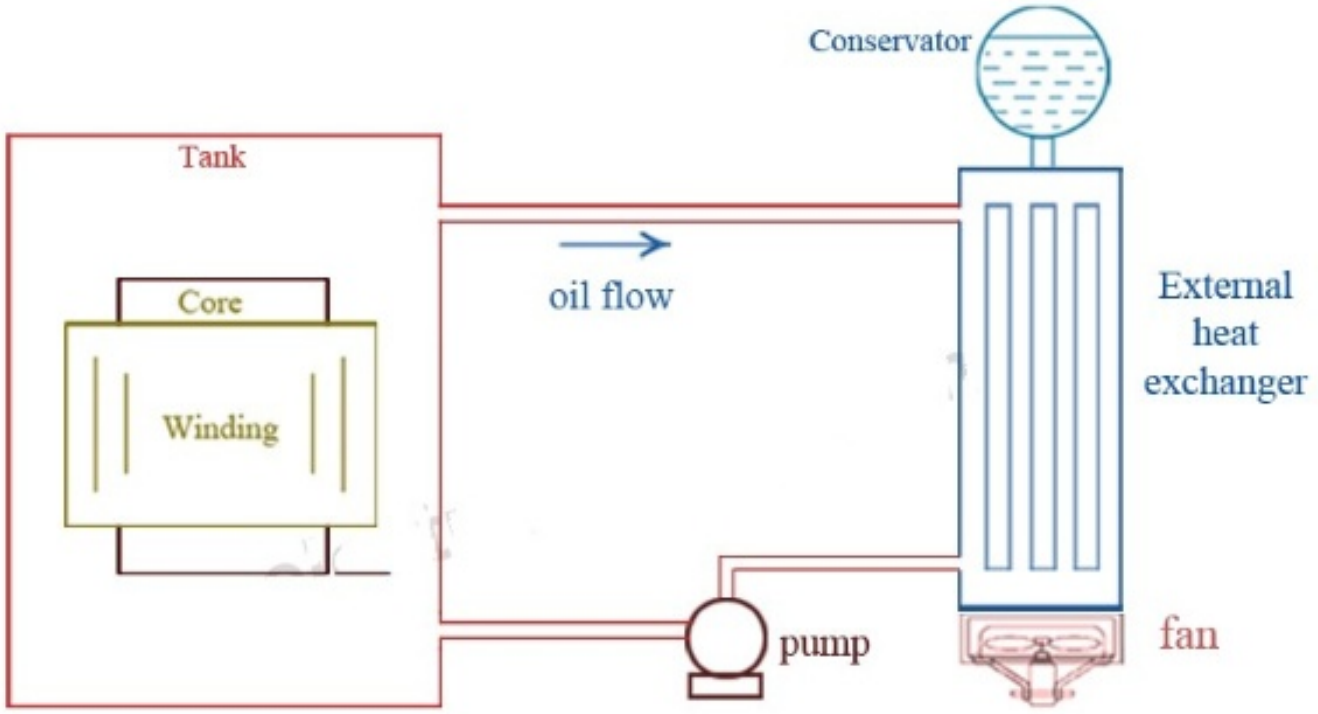

Oil Forced Air Forced (OFAF) - Cooling of Transformer

Oil Forced Water Forced (OFWF)

- This method is similar to OFAF method, but here forced water flow is used to dissipate hear from the heat exchangers.
- The oil is forced to flow through the heat exchanger with the help of a pump, where the heat is dissipated in the water which is also forced to flow.
- The heated water is taken away to cool in separate coolers. This type of cooling is used in very large transformers having rating of several hundreds MVA

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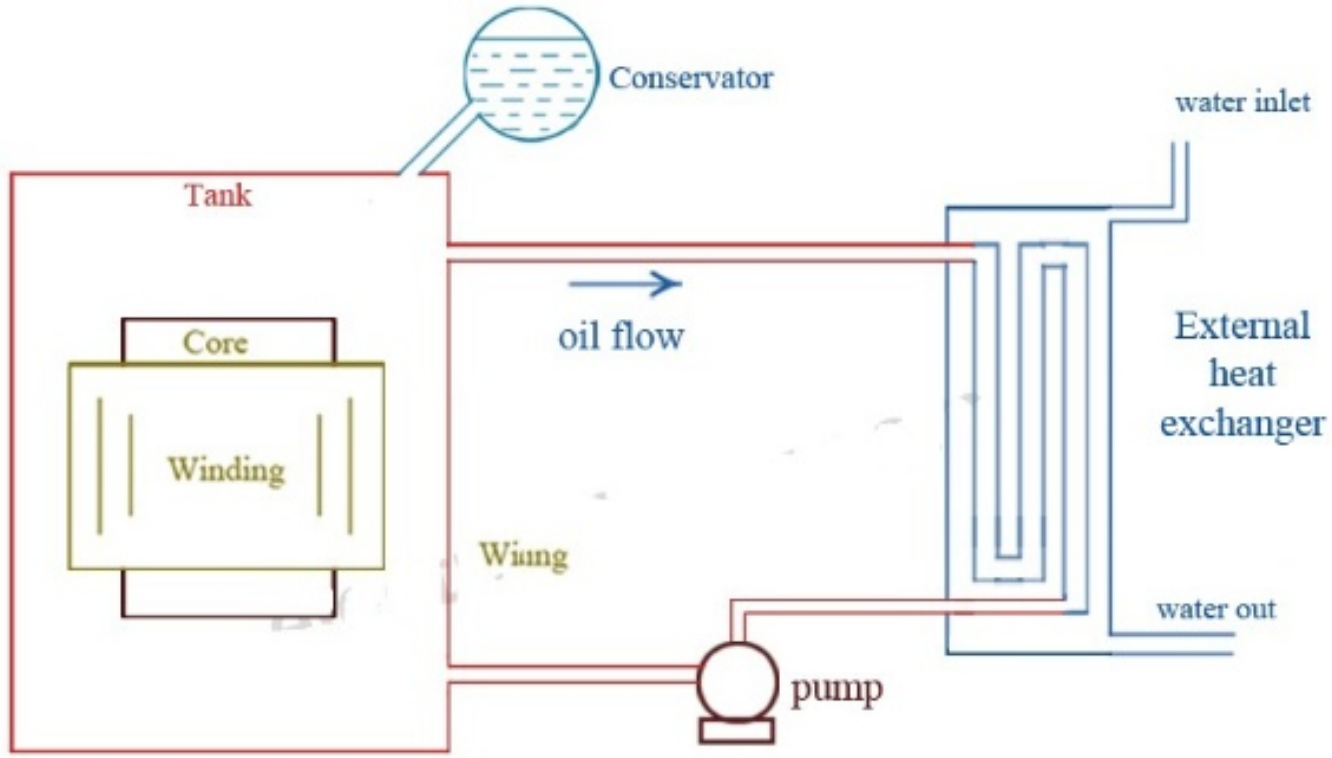

Oil Forced Water Forced (OFWF) - Cooling of Transformer

THANK YOU