Losses in Transformer

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LOSSES IN TRANSFORMER:

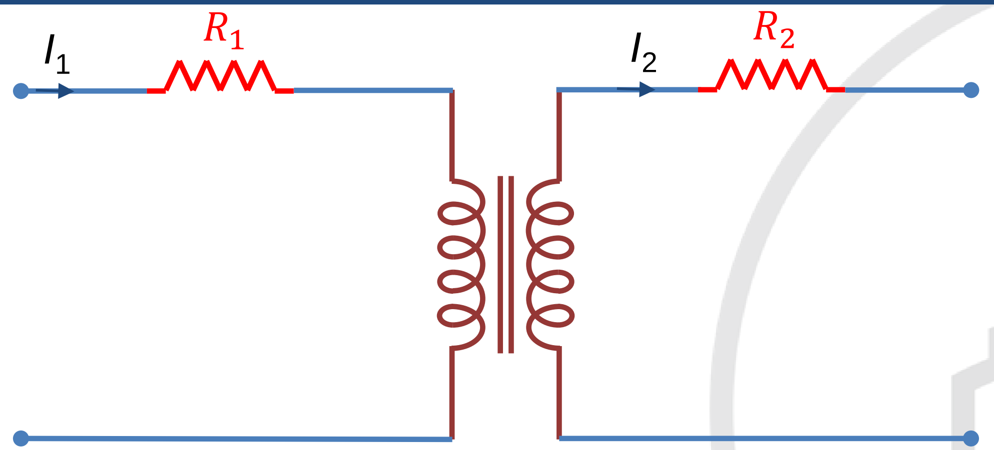
Transformer is a device which transfers the power from one circuit to the other.

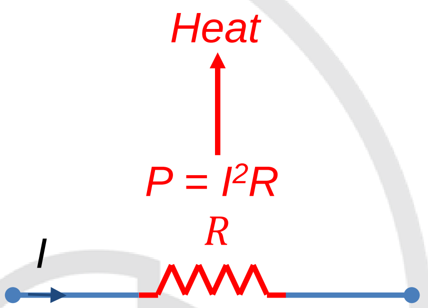
The whole input power cannot be transferred to the output circuit because some amount of power is lost in the core and windings of the transformer as a heat.

Two main losses that occur in transformer:

1) Copper losses
2) Core or iron losses
   i. Hysteresis losses
   ii. Eddy current losses

COPPER LOSSES:





Both the windings of transformer have a certain value of resistance.

When current I flows through a resistance of R Ω, the power consumed in the resistor is I^2R in the form of heat.

Thus, when the current flows through primary and secondary windings, some power is wasted in the form of heat.

This loss of power taking place in the winding due its resistance is known as copper loss.

Copper loss in primary winding = $I_1^2 R_1$ Watt

Copper loss in secondary winding = $I_2^2 R_2$ Watt

$\therefore$ Total copper loss in transformer, $W_{copper} = I_1^2 R_1 + I_2^2 R_2$ Watt

COPPER LOSSES:

$W_{copper} = I_1^2 R_1 + I_2^2 R_2$ Watt

Putting $I_1 = I_2 K$

$W_{copper} = (I_2 K)^2 R_1 + I_2^2 R_2 = I_2^2 K^2 R_1 + I_2^2 R_2$

$\therefore\ W_{copper} = I_2^2 (K^2 R_1 + R_2) = I_2^2 R_{02}$

In the same way, $W_{copper} = I_1^2 R_{01}$

Note:

When the transformer is at no load, $I_2 = 0$ and I_1 = no-load current I_0

As no load current I_0 is very small, copper loss at no-load is very small (negligible).

Copper loss is variable and it is proportional to the square of the current flowing through windings.

For correct determination of copper loss, the winding resistance at operating temperature of windings must be considered.

HYSTERESIS LOSSES:

When alternating current flows through the windings, the core material undergoes cyclic process of magnetization and demagnetization.

In this process, the flux density (*B*) lags behind the magnetizing force (*H*).

This lagging of *B* behind *H* is known as hysteresis.

Some power is wasted in the form of heat due to hysteresis called as hysteresis loss.

The hysteresis loss (in watt) is given by $W_{hys} = K_h B_m^{1.6} f V$ Watt

Where,

$K_h =$ Hysteresis coefficient whose value depends on the material

$B_m =$ Maximum flux density in Wb/m^2

$f =$ Frequency of the magnetic reversal

$V =$ Volume of core material in m^3.

Note:

Hysteresis loss depends on the applied voltage and frequency.

EDDY CURRENT LOSSES:

Alternating flux produced in the core is cut by the core.

Circulating currents are set up in the core called eddy currents.

The loss of power in the form of heat is called eddy current loss.

The eddy current loss (in watt) is given by $W_{eddy} = K_e B_m^2 f^2 t^2 V$ Watt

Where,

$K_e =$ Constant whose value depends on the material

$B_m =$ Maximum flux density in Wb/m^2

$f =$ Frequency of the magnetic reversal

$V =$ Volume of core material in m^3.

$t =$ thickness of laminations in m.

Note:

Eddy current loss depends on the square of applied frequency.

IRON LOSSES:

Total iron or core losses, $W_{iron} = W_{hys} + W_{eddy}$ (Watt)

To minimize the iron loss the core is made up of thin silicon steel laminations which are insulated from each other by varnish.

Note:

Iron loss in transformer depends on the applied voltage.

The core flux ϕ is constant from no-load to full load.

Hence, core losses in transformer are constant and are independent of the load connected across secondary.

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