losses in transformer

a) iron or Core loss (P_i) b) Copper or i^2R loss (P_c)

a) Iron loss: occur in magnetic Core of transformer.
It is Sum of hysteresis loss (P_h) and eddy Current loss (P_e)

$$P_i = P_h + P_e$$

$$P_h = K_h f B_m^x$$

$$P_e = K_e f^2 B_m^2$$

here
f = freq. of alternating f
B_m = max. flux density in C
K_h = Proportionality Constant depend on the volume and quality of Core material and units used
K_e = Proportionality Constant whose valu depends upon volume & resistiv of Core material, thickness of laminations & units used

Exponent x called Steinmetz Constant. It values varies from 1.5 to 2.5 depending upon magnetic properties of Core material. the total Core loss —

$$P_i = P_h + P_e$$

$$P_i = K_h f B_m^x + K_e f^2 B_m^2$$

P_h depends on
→ applied vtg & freq
P_e → depends on
* Square of applied vt
* independent of tr

Copper loss or I^2R loss (P_c)

I^2R loss take place in Primary & Secondary winding because of winding resistances.

total Cu loss in a xmer = Primary wdg Cu loss + Secondary wdg Cu loss

(Copper loss varies as the Square of load Current)

Separation of hysteresis & eddy current loss

$\therefore P_i = P_h + P_e$

$P_i = K_h f B_m^x + K_e f^2 B_m^2$ —— (1)

K_h = Constant whose value depend on ferromagnetic material

B_m = max. value of flux density

f = Supply freq.

* $x \rightarrow$ varies in (1.5 to 2.5 depend on material.)

for given B_m, P_h varies directly as freq. & P_e varies as Square of freq, i.e.

* $P_h \propto f$ or $P_h = af$
* $P_e \propto f^2$ or $P_e = bf^2$ * a, & b are Constant

$\therefore \boxed{P_i = af + bf^2}$

For Separation of these (2) losses the no-load test is performed on the xmer. However, Primary of xmer is connected to a Variable freq. & Variable Sinusoidal Supply & Secondary is open Circuited.

Now $V \simeq E = 4.44 f \Phi_m N$

or $\frac{V}{f} = 4.44 B_m A N$

For any xmer N & A. are Constants. therefore B_m will remain Constant if the test is conducted so that the ratio (V/f) kept Constant.

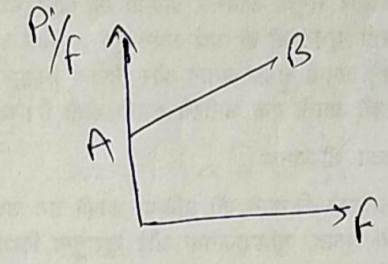
Divide eqn by f,

$$\frac{P_i}{f} = bf + a$$

During test, V & f varied together so (V/f) is kept Constant. & Core loss is obtained at diff freq.

A graph (P_i/f) versus freq. f is plotted.

Graph is Straight line AB of form $y = mx + c$



Intercept of Straight line on vertical axis gives a & Slope of line AB gives b.

a & b are P_h & P_e Constants.

Ex: In a test, P_i = 100w at 40 Hz & 72w at 30Hz find P_h & P_e at 50 Hz.

Sol^n $\quad P_i/f = a + bf$

$$\frac{100}{40} = a + 40b \quad \& \quad \frac{72}{30} = a + 30b$$

by Solving $\rightarrow$ $a = 2.1$ & $b = 0.01$

transformer

P_h at 50 Hz $\rightarrow$ $af = 2.1 \times 50 =$ (105w)

P_e at 50 Hz $\rightarrow$ $bf^2 = 0.01 \times 50^2$

$=$ (25w)