Example (2.5) A 15-KVA, 2300/230 V transformer is to be tested to determine its excitation brach components, its series impedances and its voltage regulation.

Data:

Open circuit test (low voltage side)	short circuit test (high voltage side)
$V_{oc} = 230V$	$V_{sc} = 47V$
$I_{oc} = 2.1 A$	$I_{sc} = 6.0 A$
$P_{oc} = 50 W$	$P_{sc} = 160 W$

(a) Find the eq circuit of its transformer referred to high voltage side.

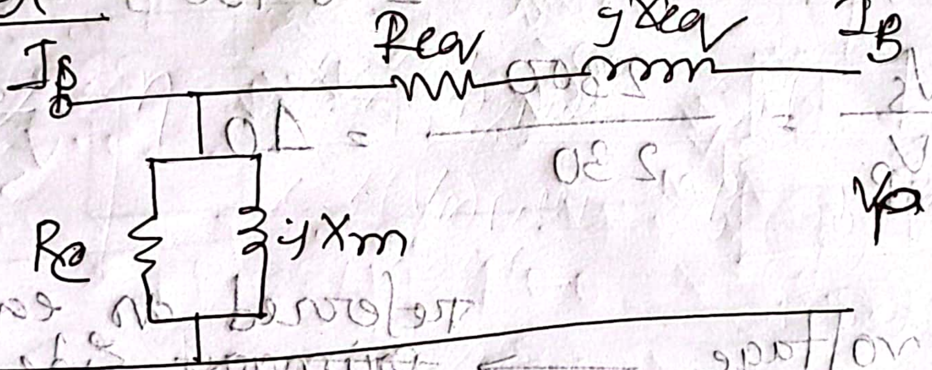
(b) for low-voltage side.

(c) Calculate the full-load voltage regulation at 0.8 lagging power factor, 1.0 power factor and 0.8 leading power factor using the exact equation for V_p.

(e) What is the efficiency of the transformer at full load with a power factor of 0.8 lagging?

Answer

(a)



sample

$P_{oc} = \cancel{15000}$ 50W

$V_{oc} = 230V$

$$R_c = \frac{(V_{oc})^2}{P_{oc}}$$

$$= \frac{(230)^2}{50} = 1058\ \Omega$$

$$X_m = \frac{(V_{oc})^2}{\sqrt{(V_{oc} I_{oc})^2 - P_{oc}^2}} = \frac{(230)^2}{\sqrt{(230 \times 2.1)^2 - (50)^2}}$$

$$= 110.115\ j\Omega$$

$$R_{eq} = \frac{P_{sc}}{I_{sc}^2} = \frac{160}{(6)^2} = 4.44$$

$$X_{eq} = \frac{\sqrt{(V_{sc} I_{sc})^2 - (P_{sc})^2}}{I_{sc}^2} = \frac{\sqrt{(47 \times 6)^2 - (160)^2}}{(6)^2}$$

$$= 6.450 \, j \, \Omega$$

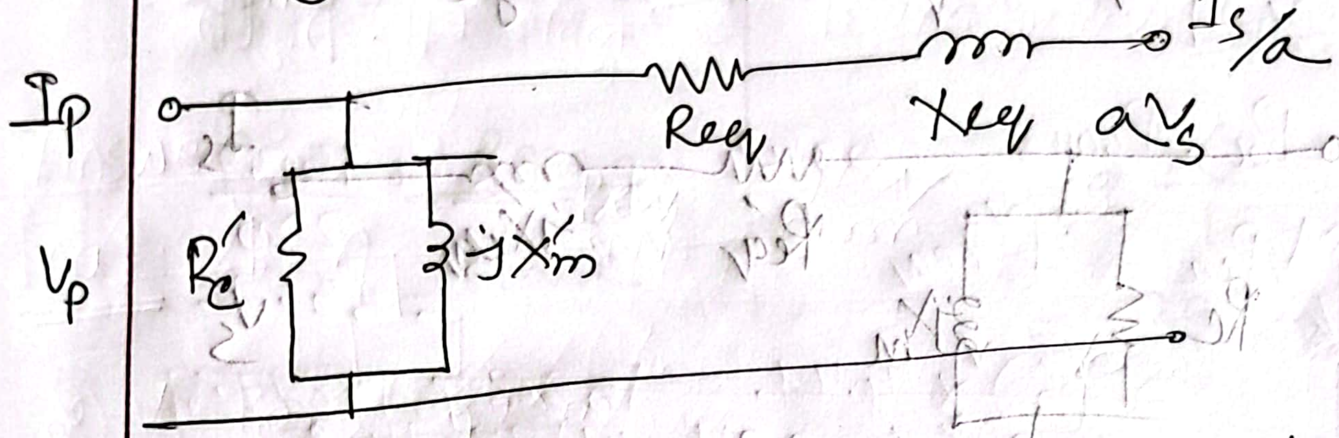
$$a = \frac{V_s}{V_p} = \frac{2300}{230} = 10$$

referred on ... circuit

Req, Xeq are $\longrightarrow$ Primary

Rc, Xm $\longrightarrow$ Secondary

at high voltage | reffered to primary



$$R_c' = R_c \times a^2 = 1058 \times 100 = 105.8\,K\Omega$$

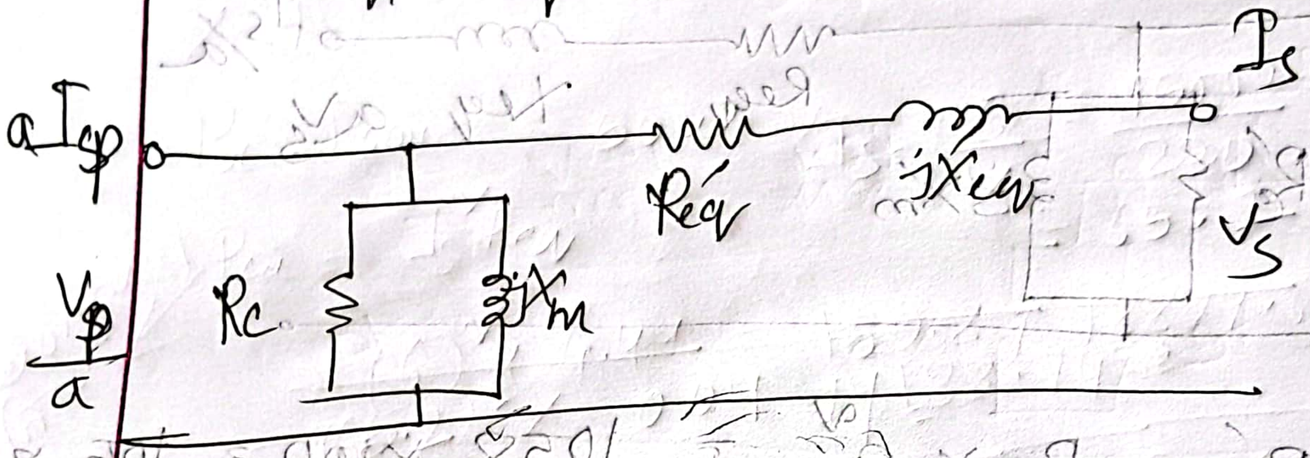
$$X_m' = X_c \times a^2 = 110.58 \times 100 = 11.0\,K\Omega$$

Req, Xeq same.

(b) At low voltage referred to secondary

(R_c, X_m same)

X_{eq}, R_{eq} will change.



~~$R_{eq} = 444\ \Omega$~~

~~$X_{eq} = 645\ j\Omega$~~

$R_{eq}' = R_{eq} \times \frac{1}{a^2} = 0.0444\ \Omega$

$X_{eq}' = X_{eq} \times \frac{1}{a^2} = 0.0645\ \Omega$

(c) $V_{reg} = \sqrt{(S_{pu} R_{pu} + \cos\theta)^2 + (S_{pu} X_{pu} + \sin\theta)^2} - 1$

$S_{pu} = \cancel{15000\ VA}\ 1\ pu$

$R_{pu} = \frac{R_{eq}}{Z_{base}}$

$\Rightarrow \frac{4.44}{352.667}$

$= 0.01258$

$Z_{base,P} = \frac{(V_S)^2}{\cancel{S_{pu}}\ S_{1}\ P}$

$\Rightarrow \frac{(2300)^2}{15000}$

$= 352.667$

$X_{pu} = \frac{X_{eq}}{Z_{base}} = \frac{6.45}{352.667} = 0.01828$

$\theta = \cos^{-1}(0.8) = 36.86$

यदि logging 36.86

leading -36.86

$V_{reg} = \sqrt{(1 \times 0.01258 + \cos(36.86))^2 + (1 \times 0.01828 + \sin(36.86))^2} - 1$

$= 1.72\ \%$

ⓔ $\eta = \dfrac{x(VA)_{full} \times P_f}{x(VA)_{full} \times P_f + P_{core} + x^2 P_{cu}}$

$x = 1$

$P_{OC} = P_{core} = 50W$

$I_s = \dfrac{S}{V_s} = \dfrac{15000}{230}$

$= 65.2$

secondary নিয়ে $P_{cu} = I_s^2 R_{eq}$

$\cancel{\Rightarrow (6)^2 \times 4.44 = 159.84} \; \cancel{18874.61}$

$= (65.2)^2 \times 0.0444 = 188.74$

$\eta = \dfrac{1 \times 15000 \times 0.8}{1 \times 15000 \times 0.8 + 50 + (1)^2 \cancel{159.84} \; \cancel{65.2} \; 188.74}$

$\cancel{= 0.98}$ $\quad 0.98$

$\cancel{= 98.28\%}$ $\quad 98\%$

for half load:

$$x = 1/2$$

$$I_s' = \left(\frac{I_s}{2}\right)$$

$$\eta = \frac{1/2 \times 15000 \times 0.8}{1/2 \times 15000 \times 0.8 + 50 + 47.18}$$

$$= 0.984$$

$$= 98.4\%$$