Tutorial - 9

1. Consider a 20 kVA, 2200/220 V, 50 Hz, single phase transformer. Core loss at rated voltage and copper loss at 80% of the full load of this transformer are 200 W and 500 W, respectively. Calculate the percentage efficiency of the transformer if the output power at the LV side of the transformer is 10 kVA at 0.9 pf lagging.

Solution -

① 20 kVA, 2200/220 V, 50 Hz, 1-ϕ Transformer

P_{core} (at rated voltage) = 200 W

P_{cu} (at 80% of rated current) = 500 W

since $P_{cu} \propto I_{rated}^2$

$$\therefore P_{cu}\text{(full load)} = P_{cu(80\%)} \times \frac{1^2}{0.8^2} = 781.25 \text{ watts}$$

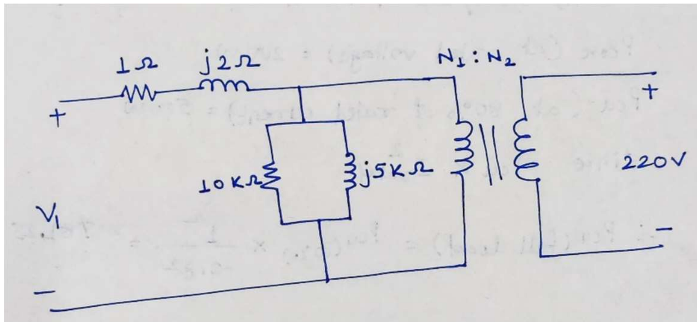
$\therefore$ at 10 kVA at 0.9 lagging,

$$x = \left(\frac{10}{20}\right) = 0.5$$

$$\therefore \eta = \frac{P_{out}}{P_{out} + P_{core} + x^2 \times P_{cu(full\text{-}load)}}$$

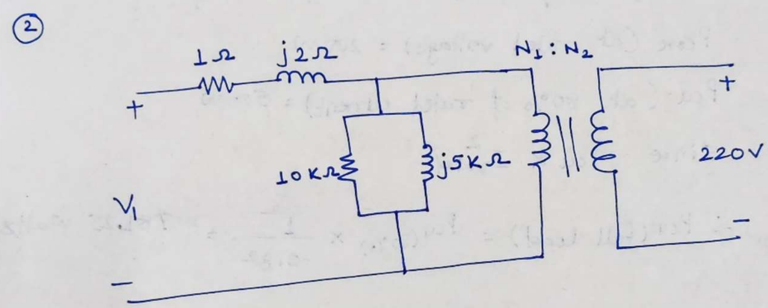
$$\% \eta = \frac{10{,}000 \times 0.9 \times 100}{10{,}000 \times 0.9 + 200 + 781.25 \times (0.5)^2} = 95.79 \%$$

2. The equivalent circuit for a 50 kVA, 2200/220 V, 50 Hz single-phase transformer is shown in figure below. Assume that the transformer is operating at rated secondary voltage and rated apparent power with a 0.8 power factor (lagging). Estimate the copper loss in watts.



Solution –

(2)



50 KVA, 2200/220 V, 50 HZ, 1-φ transformer

Iron Loss $= \dfrac{E_1^2}{R_c} = \dfrac{2200^2}{10\times10^3} = 484$ Watts

Rated Secondary Current, $I_2 = \dfrac{S_{rated}}{V_2} = \dfrac{50\times10^3}{220} = 227.27$ Amp

pf is given as 0.8 lagging $\therefore$ $\bar{I_2} = 227.27\angle -36.86^\circ$ Amp

Load current referred to HV side, $\bar{I_2'} = \dfrac{220}{2200} \times \bar{I_2} = 22.727\angle -36.86^\circ$ Amp

Exciting Current, $\bar{I_e} = \dfrac{2200\angle 0^\circ}{10\times10^3} + \dfrac{2200\angle 0^\circ}{j5\times10^3} = (0.22 - j0.44)$ Amp

Primary H.V. current $\Rightarrow$ $\bar{I_1} = \bar{I_e} + \bar{I_2'} = 23.168\angle -37.4^\circ$ Amp.

$\therefore$ Cu losses, $P_{cu} = 23.168^2 \times 1 = \cancel{28}$ $\underline{536.756}$ watts

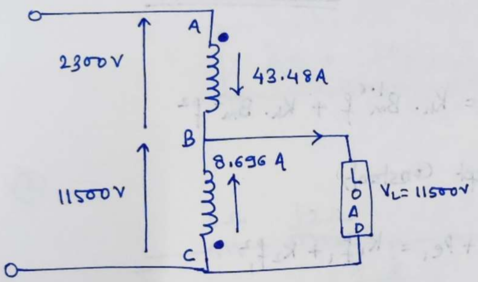
3. An 11500/2300 V transformer is rated at 100 kVA as a 2-winding transformer. If the windings are connected in series to form an autotransformer, what will be the maximum output power in kVA?

Solution -

for two winding transformer,

Rated current for 11500 V winding $= \frac{100 \times 1000}{11500} = 8.696$ Amp

Rated current for 2300 V winding $= \frac{100 \times 1000}{2300} = 43.48$ Amp



$V_{AB} = 2300V$, $V_{BC} = 11500V$

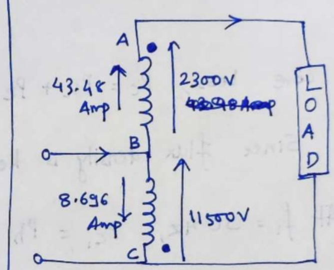
$\therefore V_H = V_{AB} + V_{BC} = 13800$ V

$V_L = V_{BC} = 11500V$

Vtg transformation Ratio $= \frac{V_H}{V_L} = \frac{13800}{11500} = \frac{6}{5}$

Load current $= 43.48 + 8.696$
$= 52.176$ Amp

power output $= 52.17 \times 11500$
$= 600$ KVA



$V_{BC} = 11500V$, $V_{AB} = 2300$ V

$\therefore V_H = V_{AB} + V_{BC} = 13800$ V

$V_L = V_{BC} = 11500$ V

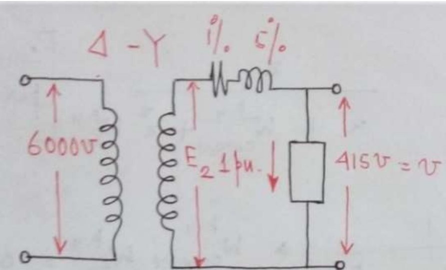
$\therefore$ Vtg transformation ratio $= \frac{13800}{11500} = \frac{6}{5}$

Load current $= 43.48$ Amp

$\therefore$ Power output $= 13800 \times 43.48$
$= 600$ KVA

4. A 3-phase delta-wye transformer has an induced emf of 6000 V on the delta-connected side. The secondary side is supplying full load current at a power factor 0.8 (lag). The line voltage at secondary is 415 V. The resistance and reactance of the winding is 1% and 5% respectively. Find the turns ratio of the transformer to the nearest integer.

Solution -



taking 415 v as 1 pu. voltage, the current will be $1\angle{-\cos^{-1}0.8}$ p.u.

induced emf $= E_2 = v + i(R + jX)$

$= 1\angle 0^\circ + 1\angle -36.87 \times (0.01 + j0.05)$ p.u.

$= 1.038\angle 1.876$ p.u.

$|E_2| = (1.038 \times 415)\,v = 430.77$ Volt

Since, the secondary side is Y-connected,

$|E_2|_{Ph} = \dfrac{430.77}{\sqrt{3}}$ Volts $= 248.7$ Volts

$\therefore$ turns ratio $= \dfrac{6000}{248.7} = 24.12$

$\simeq 24$ (ANS)