19AIE104 Introduction to Electrical Engineering

TEAM 11 BATCH A

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•Q1 --Apply A single-phase inductor coil (non-ideal, not purely inductive) used in an SMPS (UPS) connected to a supply of 220 V at 60 Hz, takes a current of 4 A. The coil dissipates 750 W.

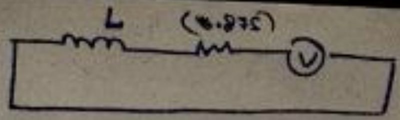
Calculate

1. The resistance and the inductance of the coil.

2.The power factor of the coil.

3.Considering the resistive power loss, estimate the efficiency of the inductor coil.

Q1



Voltage 220V
frequency 60 Hz
Current ⇒ 4A
coil (output Power) ⇒ 750 W

1.

$V = iZ$

$220 = 4\sqrt{R^2 + (X_L)^2}$

$55 = \sqrt{R^2 + (X_L)^2}$ —— ①

Calculating resistance using power dissipated

$750 = i^2 R$

$750 = (4)^2 R$

$\boxed{46.875\Omega = R}$

Now we know from ①

$(55)^2 = (46.875)^2 + (X_L)^2$

$3025 = 2197.265 + (X_L)^2$

$\sqrt{827.735} = X_L$

$\boxed{28.77 = X_L}$

$X_L = 2\pi f(L)$

$28.77 = 120\pi(L)$

$\boxed{L = 0.076\,H}$

2. We know power factor $\Rightarrow \frac{R}{Z}$ $(\cos\phi)$

or

$\Rightarrow \frac{\text{True power}}{\text{Apparent Power}}$

$\Rightarrow \frac{46.875}{55}$ or $\frac{750}{880} \Rightarrow 0.85227$

Efficiency Q1 Efficiency $\Rightarrow \dfrac{\text{True Power}}{\text{Apparent Power}} * 100$

$\Rightarrow \dfrac{750}{880} * 100$

$\Rightarrow 85.227$

•Q2 --Calculate and Analyse If the inductor coil mentioned in Q1 is used in a 230 V, 50 Hz power supply, analyse and comment on the following:

1.Change in power loss

2.Variation in power factor and impedances

3.The change in efficiency with the new power supply

4.The power factor and efficiency if a capacitor of $100\mu F$is connected in series with the inductor coil.

Q2 Details already mentioned in Q1

Old voltage → 220V   New Voltage ⇒ 230V

old freq → 60 Hz   New freq ⇒ 50Hz

Current ?   Resistance ⇒ 46.875 Ω

X_L ⇒ ?   Inductance ⇒ 0.076H

Z ⇒ ?

$(i\ Z) = 230$

$X_L' = 2\pi f(L)$

$= 100\pi(0.076)$

$= 314\left(\frac{76}{1000}\right)$

$= 23.864$

firstly let us calculate impedance

$$Z = \sqrt{(46.875)^2 + (23.864)^2}$$

$$Z = \sqrt{2197.26 + 569.49}$$

$$\boxed{Z = 52.59}$$

using this impedance and voltage we get current

$$\boxed{4.37A = \text{current}}$$

1. Power loss using i^2R we get

$$(4.37)^2(46.875)$$

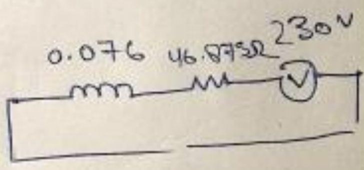
$$\boxed{\Rightarrow 895.16\ W}$$

So for change in power loss we will do

New − Old

⇒ 895.16 − 750.00

$$\boxed{\Rightarrow 145.16\ W}$$



2. Power factor ⇒ R/Z ⇒ $\frac{46.875}{52.59}$

$$\boxed{\Rightarrow 0.8912}$$

Variation ⇒ New − old

⇒ 0.8912 − 0.8522

⇒ 0.039

Q2 3.

Efficiency

New Efficiency

New Apparent Power ⇒ 1005 W

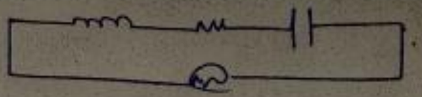
New Power Dissipated ⇒ 895.16 W

$$\text{Efficiency} \Rightarrow \frac{895.16}{1005} * 100$$

$$\Rightarrow 0.89 * 100$$

$$\Rightarrow 89\% \text{ (Approx)}$$

4. New circuit



$Z = \sqrt{R^2 + (X_L - X_C)^2}$

$R = 46.875\ \Omega$

$L = 0.076\,H$

$C = 100 \times 10^{-6}\,F$

$X_C = \frac{1}{\omega C} = \frac{1}{100\pi(10^{-6} \times 100)}$

$= \frac{10^2}{3.14} = 31.84$

$X_L = 23.864$

$X_C > X_L$

It means overall circuit have leading current

$Z = (\sqrt{2197.26 + 63.68})$

$Z = 47.54$

$230 = (47.54)(I)$

$\boxed{I = 4.83A}$

* Power factor $= \frac{R}{Z} = \frac{46.875}{47.54} = 0.986$

Q2 4

Efficiency

Apparent Power using (VI) is 1112.74W

True Power using (i^2R) is 1093.54W

$$\text{Efficiency} \Rightarrow \frac{1093.54}{1112.74} * 100$$

$$\Rightarrow 0.9827 * 100$$

$$\Rightarrow 98.27\ \%$$

•Q3 --Calculate and Analyse Consider a parallel RLC circuit composed of 100Ω, 100$\mu F$and 75mHbeing supplied by a 240 V, 50 Hz power supply.

Calculate and compare the system to the one mentioned in Q2.4.

1.Impedances,

2.Apparent power, active power, power factor, and reactive power.

3.Variation in power factor and impedances

4.The change in efficiency with the new power supply

5.The power factor and efficiency if a capacitor of 100$\mu F$is connected in series with the inductor coil

(i) Given,

$F = 50\,Hz$, $R = 100\,\Omega$, $L = 75 \times 10^{-3} H$

$C = 100 \times 10^{-6} f$.

Now, $X_L = 2\pi f.L$

$= 2 \times \pi \times 50 \times 75 \times 10^{-3}$

$= 23.56$.

$X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi.(50)(100 \times 10^{-6})} = 31.83$.

Now, Impedance (Z) $= \frac{1}{\sqrt{\frac{1}{R^2} + \left(\frac{1}{X_L} - \frac{1}{X_C}\right)^2}}$

$= \frac{1}{\sqrt{\frac{1}{(100)^2} + \left(\frac{1}{23.56} - \frac{1}{31.83}\right)^2}}$

$= 67.56$

3)

(2) (i) Apparent Power :- $= I^2 \times Z$

$= (2.4)^2 \times 100 = 576$ VA

$\boxed{I = V/R = \frac{240}{100} = 2.4}$

(ii) Reactive Power :-

$X_T = X_L - X_C$

$X_T = 0.075$

Reactive Power $= I^2 X_T$

$= (5.76)(0075)$

$= 0.432$ VAR

(iii) Power factor :-

Power factor $(\cos\phi) = \frac{I^2 R}{I^2 Z} = \frac{R}{Z} = \frac{100}{67.56}$

$= 1.48$

3)

(3) Variation in Power factor :-

$= 0.815 - 0.6586$

$= 0.1564$

Variation in impedance :

$= 167.56 - 57.5)$

$= 10.06$

4) efficiency $= \left(\frac{\text{output Power}}{\text{input Power}}\right) \times 100$

output Power = input Power - Power disipated

$$= \frac{240\left(\frac{240}{67.56}\right) - \left(\frac{240}{67.56}\right)^2 \times (67.56)}{\left(\frac{(240)^2}{67.56}\right)}$$

efficiency $= 0.0128 \times 100 = 1.28\%$