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Homework 5: due 2/19/2020

14. The primary of a transformer has twice as many turns as the secondary. ($a = 2$) The primary voltage is $220V$ and a 5Ω load is connected across the secondary. Calculate the power delivered by the transformer, as well as the primary and secondary current.

$$\begin{aligned}
V_p &= 220V;\ Z_s = 5\Omega \\
V_s &= \frac{V_p}{a} = \frac{220V}{2} = 110V \\
P &= \frac{V_s^2}{Z_s} = \frac{110V^2}{5\Omega} \\
P &= 2420W \\
\\
I_s &= \frac{V_s}{Z_s} = \frac{110V}{5\Omega} \\
I_s &= 22A \\
\\
I_p &= \frac{I_s}{a} = \frac{22A}{2} \\
I_p &= 11A \\
\\
&\overline{\underline{|P = 2420W;\ I_s = 22A;\ I_p = 11A|}}
\end{aligned} \tag{1}$$

21. Explain why the secondary voltage of a practical transformer decreases with increasing resistive loads.

The voltage decreases, because there is more voltage going to the internal losses.

25. A 66.7MVA transformer has an efficiency of 99.3% when it delivers full power to a load having a power factor of 100%.
    1. Calculate the losses in the transformer under these conditions.

$$\begin{aligned}
efficiency &= \frac{P_s}{P_p} \\
P_s &= 66.7MW * 0.993 = 66.2331MW \\
losses &= P_p - P_s = 66.7MW - 66.2331MW \\
&\overline{\underline{|losses = 466.9kW|}}
\end{aligned} \tag{2}$$

    2. Calculate the losses and efficiency when the transformer delivers 66.7MVA to a load having a power factor of 80%.

$$\begin{gathered} losses\ are\ consistent \\ \therefore \\ losses = 466.9kW \end{gathered} \tag{3}$$

$$P_s = 66.2MW;\ S = \frac{P}{pf} = \frac{66.2MW}{0.8} = 82.75MVA$$

$$S_p = \frac{66.7MW}{0.8} = 83.375MVA$$

$$efficiency = \frac{S_s}{S_p} = \frac{83.375MVA}{82.75MVA}$$

$$\boxed{losses = 466.9kW;\ efficiency = 98.7\%}$$

30. During a short-circuit test on a 10MVA, 66kV-7.6kV transformer, the following results were obtained.

$$\begin{gathered} E_g = 2640V \\ I_{sc} = 72A \\ P_{sc} = 9.85kW \end{gathered} \tag{4}$$

Calculate:

1. The total resistance and total leakage reactance referred to the 66kV primary side.

$$\begin{gathered} 10MVA >> 100kVA \\ \therefore \\ Z \approx X \end{gathered} \tag{5}$$

$$Z = \frac{V}{I} = \frac{2640V}{72A} \approx 37\Omega$$

$$\boxed{R \approx 0\Omega;\ X \approx 37\Omega}$$

2. The nominal impedance of the transformer referred to the primary side.

$$Z_n = \frac{E^2}{S_n} = \frac{(66kV)^2}{10MVA} \tag{6}$$

$$\boxed{Z_n = 435.6\Omega}$$

3. The percent impedance of the transformer.

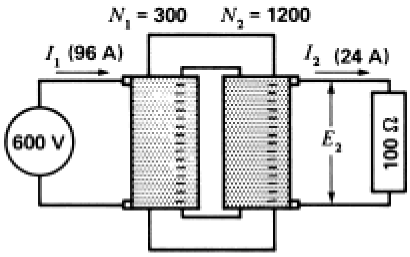
$$Z_p(pu) = \frac{Z_p}{Z_{n_p}} = \frac{37\Omega}{435.6\Omega} \tag{7}$$

$$\boxed{Z_p(pu) = 8.42\%}$$

31. In the above problem, if the iron losses at rated voltage are 35kW, calculate the full-load efficiency of the transformer if the power factor of the load is 85%.

$$\begin{aligned} 35kW@pf = 0.85;\ S = \frac{P}{pf} = \frac{35kW}{0.85} = 41.2kVA \\ efficiency = \frac{S_s}{S_p} = \frac{10MVA - 41.2kVA}{10MVA} \\ \boxed{efficiency = 99.5\%} \end{aligned} \tag{8}$$

33. If a transformer were actually built according to the below diagram, it would have very poor voltage regulation. Explain why, and propose a method for improving it.



When the load is reflected across the transformer, it becomes significantly smaller, where the internal losses are significant.

One can change this in as simple a step as changing the sides that the power and the load are connected to, although if current or voltage requirements exist, it may be more difficult.