17/ENG06/073
mechanical engineering
EEE326

PIRAH OKUNCIADE SHEDRACK

① A 25 kVA, 415 V, Three phase, 4-pole, 60Hz wye-connected synchronous generator has a synchronous reactance of 1.5Ω/phase and negligible stator resistance. The generator is connected to an infinite bus (or constant voltage magnitude and constant frequency) of 415 V and 60 Hz

② Determine the excitation voltage, E_a when the machine is delivering rated kVA at 0.8 PF lagging

$$E_a = V_t - jI_aX_s \quad : V_L = 415V, S = 25kVA = 25000VA$$

$$V_t = \frac{V_L}{\sqrt{3}} = \frac{415}{\sqrt{3}} = 239.6V$$

$X_s = 1.5\Omega$; PF = 0.8 lagging; $\therefore \theta = \cos^{-1}(-0.8) = 143.13°$

$$I_2 = \frac{S}{V\sqrt{3}} = \frac{25000}{415\sqrt{3}} = 34.78A \angle 143.13°$$

$$\therefore E_a = 239.6 - j[(34.78\angle 143.13)(1.5)]$$

$$E_a = 270.90 + j41.74$$

$$E_a = 274.098V \angle 8.76°$$

⑤ The field excitation current I_f is increased by 20% without changing the power input for the prime mover. Find the armature current in a power factor reactive power applied by the machine.

$\therefore$ 20% increase = 110.2 - 1.2.

ϕ $\delta = 8.76°$

$$E_a' = 1.2 \times 274.098 = 328.92V.$$

$$\therefore \frac{V_t E_a}{X_s}\sin\delta = \frac{V_t E_a'\sin\delta''}{X_s} \quad \therefore \sin\delta' = \frac{E_a}{E_a'}\sin\delta \rightarrow \frac{274.098}{328.92} \times \sin 8.76°$$

$\sin\delta' = 0.1269 \quad \therefore \delta = \sin^{-1}(0.1269)$

$\delta' = 7.29°$

(c) $\dot{I}_A = \frac{E_f' - V_t}{jX_s} = \frac{328.92\angle 7.29° - 239.6\angle 0}{j1.5} = 27.42 - j57.77$

$I_A \doteq 64.13A\angle -64.28°$

(d) power factor $= \cos(-64.28°) = 0.434$ lagging

(e) $Q = 3V_t I_a \sin\theta = 3 \times 239.6 \times 64.13 \times \sin(64.28) = 41529.65$ VAR

f) with the field excitation current it as in part (a) the input power from the prime mover is increased very slowly. what is the steady limit

2. Determine the stator current in power factor and reactive power q.

At max power $\delta = 90°$

$P_{max} = \frac{3E_a V_t}{X_s} = \frac{3 \times 274.098 \times 239.6}{1.5} = 131347.76W = 131.34$ kW

$I_{max} = \frac{\dot{E}_a - V_t}{jX_s} = \frac{274.098\angle 90° - 239.6\angle 0}{1.5j} = 242.71A\angle 44.16°$

power factor $= \cos(44.16) = 0.7529$ leading

$Q_{max} = 3V_t I_{max} \sin(44.16°)$

$3 \times 239.6 \times 242.71 \times 0.6582 = 114129.54$ VAR $= 114.129$ kVAR