Raj. Abraham Oluwatobi
17/ENG06/074
Mechanical Engineering
Elect Assignment 6

A. Determine the excitation voltage, E_a when the machine is delivering rated kVA of 0.8 PF lagging

$E_a = V_t - jI_aX_s$, $V_t = 415V$; $S = 25kVA = 25000VA$

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

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

$I_a = \frac{S}{V_t\sqrt{3}} = \frac{25000}{415\cdot\sqrt{3}} = 34.78A \angle 143.13°$

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

$E_a = 270.90 + j41.74$

$E_a = 274.098V \angle 8.76°$

B. The field excitation current I_f is increased by 20% without changing the power input from the prime mover. Find the stator current I_A, power factor and reactive power Q supplied by the machines.

$\therefore$ 20% increase $= 1 + 0.2 = 1.2$

$\delta = 8.76°$

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

$\therefore \frac{V_t E_a \sin\delta}{X_s} = \frac{V_t E_a' \sin\delta'}{X_s}$

$\therefore \sin\delta' = \frac{E_a \sin\delta}{E_a'} = \frac{274.098}{328.92V} \times \sin 8.76°$

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

$\delta' = 7.29°$

I. $I_A' = \frac{E_A' - V_t}{jX_s} = \frac{328.92\angle 7.29° - 239.6\angle 0}{j1.5} = 27.82 - j57.77$.

$I_A' = 64.13A \angle -64.28°$

II. Power factor $= \cos(-64.28°) = 0.434$ lagging

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

C. With the field excitation current if as in part (a), the input power from the prime mover is increased very slowly. What is the steady state limit? Determine stator current I_A, power factor and reactive power Q.

At max power $\delta = 90°$

I. $P_{max} = \frac{3E_f V_t}{X_s} = \frac{3 \times 274.098 \times 239.6}{1.5} = 131347.76$ W
$= 131.347$ kW

II. $I_{max} = \frac{E_f - V_t}{jX_s} = \frac{274.098 \angle 90° - 239.6 \angle 0}{1.5j} = 242.71A \angle 41.16°$

III. Power factor $= \cos(41.16°) = 0.7529$ leading

IV. $Q_{max} = 3V_t I_{amax} \sin(41.16°)$
$= 3 \times 239.6 \times 242.71 \times 0.6582$
$= 114829.54$ VAR
$= 114.829$ KVAR