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17/ENG06/067

Mechanical

1) $E_a = V_t - jI_a X_s$, $V_L = 415V$, $S = 25KVA = 25000VA$

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

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

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

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

$E_a = 270.90 + j41.74 = 274.098V\angle 8.76°$

(b) 20% increase $= 1 + 0.2 = 1.2$, $\delta = 8.76°$

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

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

$\sin\delta' = 0.1269 \therefore \delta = 7.29°$

(c) $I_A' = \frac{E_a' - V_t}{jX_s} = \frac{32892\angle 7.29° - 239.6\angle 0}{j1.5} = 27.82 - j57.77 = 64.13A\angle -64.28°$

(cii) $pf = \cos(-64.28°) = 0.434$ lagging

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

(e) At max power, $\delta = 90°$

$P_{max} = \frac{3E_a V_t}{X_s} = \frac{3\times 274.098\times 239.6}{1.5} = 131347.76KW = 131.347KW$

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

$pf = \cos(41.16°) = 0.7529$ leading

$Q_{max} = 3V_t I_{a\,max} \sin(41.16°)$

$= 3\times 239.6 \times 242.71 \times 0.6582 = 114829.54$ VAR $= 114.829$ KVAR