Industrial Utilization of Electrical Power Assignment

(a) (i) Brightness of snow

Illumination $(E) = \frac{\text{Luminous flux } (I)}{\text{Area } (A)}$

Brightness $= \frac{I}{A}$ (Cd/m^2)

$E = \pi \times L$

$L = \frac{E}{\pi}$

Considering the reflection factor of 85% = 0.85

$L = \frac{44000}{\pi} \times 0.85$

$= 11.905 \times 10^3 \, Cd/m^2$

(ii) $L = \frac{E}{\pi} = \frac{0.22}{\pi} \times 0.85$

$= 59.52 \times 10^{-3} \, Cd/m^2$

(b) diameter (D) = 22

luminous intensity (I) = 120 cd or 120 lumens

30% is absorbed by the globe

(i) Luminance of globe:

flux/~~intensity~~ emitted by the source

$I = \frac{\phi}{\omega}$

$\phi = \omega I$

$\phi = 120 \times 4\pi$ lumens

If 30% is absorbed:

$\phi = \frac{120 \times 4\pi}{100} \times 30$

$= 120 \times 4\pi \times 0.3$

$= 144\pi$

∴ flux emitted by the globe

$= 120 \times 4\pi - 144\pi$

$= 336\pi$ lumens

Illumination/luminance (E) = $\frac{\text{luminous flux}}{\text{Area}} = \frac{336\pi}{\pi \times 0.22^2}$

$= 6942.15$ lumens/m²

(ii) candle power = $\frac{lumen}{\omega} = \frac{336\pi}{4\pi} = 84$ candelas

(c) Area = $75 cm^2$

thickness = 2 cm

heat change = 80 - 30 = 50°C

Time = 8 minutes

$\varepsilon_r = 6.5$

specific heat = 0.255 cal/g°C

density (ρ) = 0.55 g/cm³

$\cos\theta = 0.04$

F = 20 MHz

Voltage = ?

current input = ?

Note: Assume 15% heat input to slab is wasted.

heat required = $mc\Delta\theta$

$Density = \frac{Mass}{Volume}$

M = density x Volume

M = 0.55 x 75 x 2

= 82.5g

$$C = \frac{\varepsilon_0 \varepsilon_r A}{t} = \frac{8.85\times10^{-12}\times 65\times 75\times10^{-4}}{2\times10^{-2}}$$

$$= 21.57\times10^{-12} f$$

$$\omega = 2\pi f = 2\pi\times 20\times10^{6}$$

$$= 125.664\times10^{6}\ rad/s$$

$$P.f = \cos\phi = 0.04$$

$$\phi = \cos^{-1} 0.04$$

$$\phi = 87.7$$

$$\delta = 90 - \phi = 90 - 87.7 = 2.3^{\circ}$$

$\therefore$ heat required $= Mc\Delta\theta$

$$= 82.5\times 0.255\times 50$$

$$= 1051.88\ cal.$$

Total heat required $= 1051.88\times\frac{85}{100}$ (because 15% loss)

$$= 894.098\ cal$$

Recall:

$$1\ Cal = 4.186\ (w.s)\ J$$

$$894.098 = x$$

$$x = 3742.7\ (w.s)$$

Power input = ~~8741~~ 3742.7 (W-s)

$$P = \frac{Energy}{Time} = \frac{3742.7}{8\times60} = 7.797\,W$$

(change minute to seconds)

$$P_0 = V^2 \omega C \tan\delta$$

$$7.797 = V^2 \times 125.664\times10^6 \times 21.57\times10^{-12} \times \tan 2.3^\circ$$

$$V^2 = \frac{7.797}{125.664\times10^6 \times 21.57\times10^{-12} \times \tan 2.3^\circ}$$

$$V = 267.62\,V$$

$$P = IV\cos\phi$$

$$I = \frac{7.797}{267.62\times0.04}$$

$$= 0.7284\,A$$