1. $D = 1500\ m$

Schedule speed $= 36\ km/h = 36 \times 5/18 = 10\ m/s$

$\beta = 3\ km/h/s = 3 \times 5/18 = 5/6\ m/s^2$

Schedule time of run $= 1500/10 = 150\ s$

Actual time of run $= 150 - 25 = 125\ s$

$$V_a = \frac{1500}{125} = 12\ m/s$$

$$V_m = 1.25 \times 12 = 15\ m/s$$

$$k = \frac{D}{V_m^2}\left(\frac{V_m}{V_a} - 1\right)$$

$$= \frac{1500}{15^2}(1.25 - 1) = 5/3$$

$$K = \frac{1}{2}\left(\frac{1}{\alpha} + \frac{1}{\beta}\right)$$

$\alpha = 0.47\ m/s^2 = 0.47 \times 18/5 = 1.7\ km/h/s$

2. $V_a = 36\ km/h = 36 \times 5/18 = 10\ m/s$

$\alpha = 1.8\ km/h/s = 1.8 \times 5/18 = 0.5\ m/s^2$

$\beta = 3.6\ km/h/s = 3.6 \times 5/18 = 1.0\ m/s^2$

$t = D/V_a = 2000/10 = 200\ s$

$$k = \frac{(\alpha + \beta)}{2\alpha\beta} = \frac{0.5 + 1.0}{2 \times 0.5 \times 1} = 1.5$$

$$V_m = \frac{1 - \sqrt{t^2 - 4kD}}{2k} = \frac{200 - \sqrt{200^2 - 4 \times 1.5 \times 2000}}{2 \times 1.5}$$

$= 11\ m/s = 11 \times 18/5$

$= 39.6\ km/h$

3. total surface area of tank = $6l^2$

$6l^2 = 6$ or $l = 6/6 = 1m^2$

Volume of the tank = $l^3 = 1m^3$

Volume of water to be heated daily = $6 \times \{1 \times 0.9\} = 5.4m^3$

Mass of water to be heated daily = $5.4 \times 1000 = 5400kg$

Heat required to raise the temperature of water = $5400 \times 4200 (65 - 20)$

$= 1020MJ = 1020/3.6 = 283.3kWh$

Daily loss from the surface of the tank = $6.3 \times 6 \times (65-20) \times 24/1000 = 40.8kWh$

Energy supply per day = $283.3 + 40.8 = 324.1kWh$

Loading in kW = $324.1/24 = 13.5kW$

Efficiency of the tank = $283.3 \times 100/324.1 = 87.4\%$

4. Secondary Current $I_2 = P/V_2 \cos\theta = \frac{600 \times 10^3}{20 \times 0.6} = 5 \times 10^4 A$

$V_2 = 20(0.6 + j0.8) = (12 + j16)V$

$Z_2 = \frac{(12 + j16)}{(5 \times 10^4)}$

$= (2.4 + j3.2) \times 10^{-4} \Omega$

If $Z_2$ is doubled

$\therefore Z_2 = (4.8 + j3.2) \times 10^{-4} \Omega$

$I_2 = \frac{20}{(4.8 \times j3.2) \times 10^{-4}}$

$= 3.466 < -33.7° \times 10^4 A$

$pf = \cos 33.7 = 0.832$

$\therefore$ Power absorbed = $20 \times 3.466 \times 10^4 \times 0.832 \times 10^4$

$= 580 kW$

Without Reflector

5. $E = \frac{300}{20^2} = 0.75\ lm/m^2$

$\theta = \tan^{-1}\left(\frac{10}{20}\right) = 26.6°$

$\therefore E = \frac{300}{0.89 \times 500} = 0.534\ lm/m^2$

With Reflector

Luminous output of the lamp $= 300 \times 4\pi$

Flux directed by the reflector $= 0.5 \times 1200\pi$

$= 600\pi\ lm$

Illumination produced on the disc $= \frac{600\pi}{100\pi}$

$= 6\ lm/m^2$