Solution Mid-Sem Exam

Sub: Utilization of Electrical Power

6th Sem, Electrical Engg. Deptt. Code: EE 031616

Ans 1. (i) → (c) Mainline Services

(ii) → (d) Urban and Sub-urban Services.

(iii) → (b) Dielectric heating

(iv) → (b) Plugging

(v) → (a) Frequency

Ans: 2. The advantages and disadvantages of electric traction are as follows:

(A) Advantages:

(i) Cleaniness

(ii) High Starting torque.

(iii) Flexibility of operation

(iv) Maintenance

(v) Less starting time

(vi) Smooth Braking

(vii) Absence of unbalanced forces.

(viii) saving in high grade coal

(ix) Increased in the line capacity.

(x) cleaner, quicker and more convenience.

Dis-advantages:

(i) High capital outlay on overhead supply system.

(ii) Continuous power supply needed

(iii) communication interference

(iv) Traction is tied upto electrified routes.

(v) Negative booster needed

Ans: 3. In order to make actual speed time diagram amenable to calculations, simplified speed time curve are taken in such a way as to cause least error and at the same time calculations are made easy.

In figure: 1 OABC is the actual speed time

The basis of constructing simplified speed-time curves to keep both acceleration and retardation values same and area under actual and simplified curves.

The actual speed time curve may be approximated as

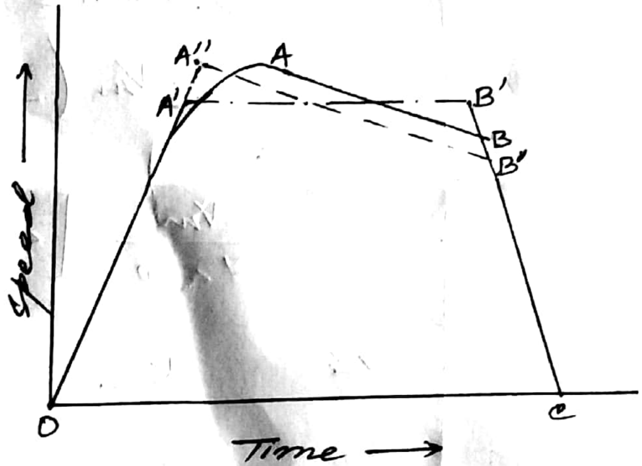

Figure: 1

(1) ~~Maxiaf~~ Trapezoidal speed-time curve: It gives closer approximation of the main line services.

(ii) Quadrilateral speed-time curve: It gives closer approximation for urban and sub-urban services.

(i) Trapezoidal speed time curve:

V_m : Maximum speed attained

t_1 : Acceleration time sec.

t_2 = Time of retardation

D = Total distance i.e area under OABC

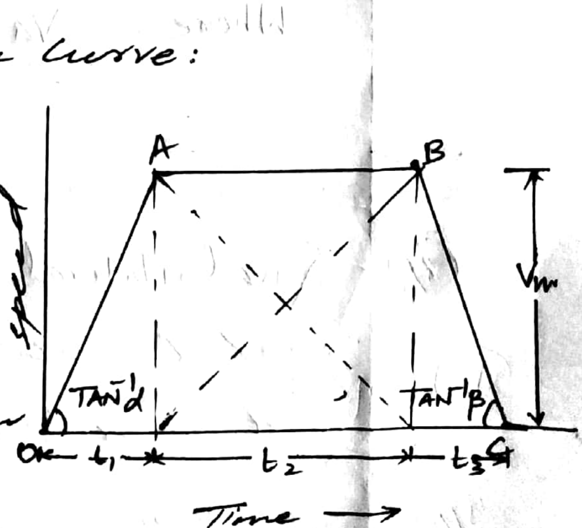

Figure: 2

Total distance $D = OAE + AEB + BEC$

$= OAE + DEB + BEC$

$= OAE + CED$

$= \frac{1}{2} AD \cdot OE + \frac{1}{2} BE \cdot DC$

$= \frac{1}{2} V_m \left(\frac{T - t_3}{3600} \right) + \frac{1}{2} V_m \left(\frac{T - t_1}{3600} \right)$

$= \frac{V_m}{7200} \left[2T - t_3 - t_1 \right] = \frac{V_m}{7200} \left[2T - V_m \left(\frac{1}{\alpha} + \frac{1}{\beta} \right) \right]$

If $K = \frac{\alpha + \beta}{2\alpha\beta}$

$\Rightarrow D = \frac{V_m}{3600} \left[T - V_m K \right]$ —— (1)

or $K V_m^2 - 2 V_m T + 3600 D = 00$

$V_m = \frac{T \pm \sqrt{T^2 - 14400 KD}}{2K}$ —— (2)

From eqn (1) & (2)

$\frac{1}{\alpha} + \frac{1}{\beta} = \frac{7200 D}{V_m^2} \left[\frac{V_m}{V_a} - 1 \right]$

Where $V_a = \frac{3600 D}{T}$

(ii) Quadrilateral time curve: This is a approximated speed-time curve for the urban and suburban services. shown in figure 2.

Here Total distance $D =$ Area $OABC$

$= OAE + AEB + EBC$

$= OAE + DEB + EBC$

$= OAE + DBC$

$$= \frac{1}{2} v_1\left(\frac{T - t_3}{3600}\right) + \frac{1}{2} v_2\left(\frac{T - t_1}{3600}\right)$$

$$= \frac{1}{7200}\left[T(v_1 + v_2) - (v_1 t_3 + v_2 t_1)\right]$$

$$= \frac{1}{7200}\left[T(v_1 + v_2) - v_1 v_2\left(\frac{1}{\alpha} + \frac{1}{\beta}\right)\right] \quad \text{—— (1)}$$

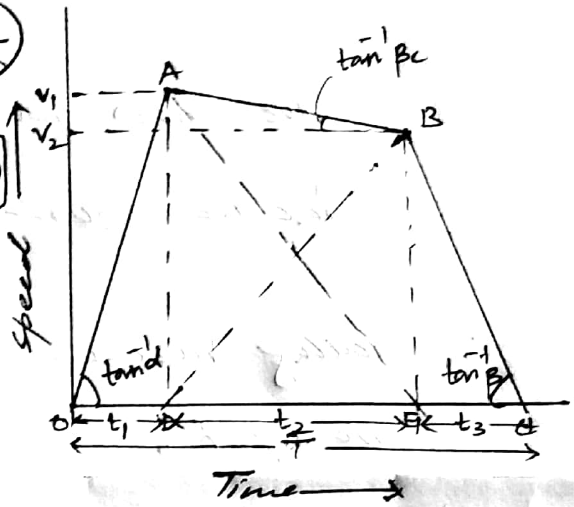

Figure : 2

$$V_2 = V_1 - \beta_c t_2$$

$$= V_1 - \beta_c (T - t_1 - t_3)$$

$$= V_1 - \beta_c\left(T - \frac{V_1}{\alpha} - \frac{V_2}{\beta}\right)$$

$$\therefore \left(V_2 - \frac{\beta_c}{\beta} V_2\right) = V_1 - \beta_c\left(T - \frac{V_1}{\alpha}\right)$$

$$\therefore V_2 = \frac{V_1 - \beta_c T + \frac{\beta_c}{\alpha} V_1}{1 - \frac{\beta_c}{\beta}} \quad \text{—— (2)}$$

Solving equ (1) & (2) We may get values of D, V_1 or V_2.

Ans. (4). Tractive effort may be given by

$$F = \eta \frac{T}{r_w} \gamma$$

$$= 0.9 \times \frac{6000 \times 4}{0.45}$$

$$= 192000 \text{ Newtons.}$$

Given are
$\eta = 0.9$
$T = 6000$ Nm
$r_w = 0.45$ mtr
γ = gear ratio = 4

We know that

Tractive effort $= F_t = 277.8\,We\alpha + 9.81\,WG + Wr$ —— (1)

Putting various values in eqn (1)

We get:

$$192000 = 277.8(1.1 \times 200)\alpha + 9.81 \times 200 \times 30 + 200 \times 50$$

$$\alpha = \frac{960 - 344.3}{302.58} = 2.01 \text{ kmphps.}$$

$$\Rightarrow t_1 = \frac{V_m}{\alpha} = \frac{50}{2.01} = 24.8 \text{ sec.}$$

$$\Rightarrow \boxed{t_1 = 24.8 \text{ sec.}}$$

Ans.

Ans: (5) Given are

$P = 20\,kW$, Supply voltage $= 220V$

$K = 0.57$, $T_1 = 1170°c$, $T_2 = 500°c$

$e = 0.95$, $\rho = 1.09\,\mu\Omega m$

$d = ?$ $l = ?$ $t_1 = ?$

$$R = \frac{V^2}{P} = \frac{220 \times 220}{20 \times 1000} = 2.42 \text{ Ohms.}$$

$$R = \rho \frac{L}{A} \Rightarrow 2.42 = 1.09 \times 10^{-6} \times \frac{L}{\frac{\pi}{4} d^2}$$

$$\Rightarrow \frac{L}{d^2} = 174{,}0000 \text{ ——— (1)}$$

$$H = 5.72 \times 0.57 \times 0.95 \left[\left(\frac{273 + 1170}{100} \right)^4 - \left(\frac{273 + 500}{100} \right)^4 \right] \text{ W/sq.m}$$

$$= 3.09 \left(14.43^4 - 7.73^4 \right) = 12 \times 10^4 \text{ W/sq.m}$$

Also $P = H \pi d L$

$$\Rightarrow 20{,}000 = 12 \times 10^4 \pi d L$$

$$\Rightarrow dL = \frac{2}{\pi\, 12} = 0.053. \Rightarrow d^2 L^2 = (0.053)^2 \text{ ——— (2)}$$

Solving eqn (1) & (2), we get

$$L^3 = 1740000 \times 0.053 \times 0.053 = 4900$$

$$\Rightarrow d = \frac{0.53}{17} = 0.312 \text{ mts.}$$

Taking the outside diameter of the coil as 6 times or mean diameter of coil as 5 times the diameter of wire, we get:

diameter of the coil $= 5 \times 0.312 = 1.60$ cm

Final temperature (When Charge is Cold) of the elements : is given by

$$12 \times 10^4 = 5.72 \times 0.57 \times 0.95 \left[\left(\frac{T_1}{100} \right)^4 - \left(\frac{273 + 20}{100} \right)^4 \right]$$

$$\therefore \quad = 3.09 \left[\left(\frac{T_1}{100} \right)^4 - (2.93)^4 \right]$$

$$\left(\frac{T_1}{100}\right)^4 - 74 = \frac{12 \times 10^4}{3.09} = 38800$$

$$\therefore \quad \frac{T_1}{100} = 14.03$$

$T_1 = 1403°$ kelvin.

$\Rightarrow \quad t_1 = 1403 - 273 = 1130°c$

$\Rightarrow \quad \boxed{t_1 = 1130°c}$ **Ans.**

THE END