~~2d5. Spring~~

6\. (b) A subtrain consist of a motor and trailor coaches in the ratio 1:1. Each motor coach is driven by four dc motor and reduction gear with gear ratio 0.4 All wheels in motor coach are driving wheels and trailor coach has same no. of wheels as motor coach. Each wheel has radius 0.54 m and weight 450 kg. Mass of each motor armature is 0.48 tonne and avg diameter 0.5 m, the combined weight of one motor and trailor coach is 40 tonne when fully loaded. Determine the coupling torque required per motor to accelerate the train to 5 kmphs. Assume train resistance to be 20 N/tonne of train weight

Soln:-

Dead weight $(M) = 40$ tonnes

acceleration $(\alpha) = 5$ kmphps

Moment of inertia of one wheel $(J_W) = \frac{1}{2} MR^2$

$$= \frac{1}{2} \times 450 \times (0.54)^2$$

$$= 65.61 \text{ kg-m}^2$$

Number of wheels $= 2 \times (4 \times 2) = 16$

Combined inertia of all wheels $(J_1) = 16 \times 65.61$

$$= 1049.76 \text{ kg-m}^2$$

Combined inertia of all motors (J_m)

$$= 4 \times \left[\frac{1}{2} \times 480 \times \left(\frac{0.5}{2}\right)^2\right] = 60 \text{ kg-m}^2$$

Moment of inertia of motors referred to wheels

$$J_2 = \frac{J_M}{a^2} = \frac{60}{(0.4)^2} = 375 \text{ kg-m}^2$$

Tractive effort to driving rotating parts :

$$F_{a2} = (J_1 + J_2) \times \frac{\alpha \times 1000}{3600 R} = (1049.76 + 375) \times \frac{5 \times 1000}{3600 \times 0.54}$$

$$= 3664.5\ N$$

Tractive effort required to accelerate the train mass horizontally (F_{a1}) $= 277.8\ M\alpha$

$$= 277.8 \times 40 \times 5 = 55560\ N$$

Tractive effort required to overcome the train resistance (F_r) $= rM = 20 \times 40 = 800\ N$

∴ Total tractive effort required is

$$F_t = F_{a1} + F_{a2} + F_r = 55560 + 3664.5 + 800$$

$$= 60024.5\ N$$

Assuming 100% transmission efficiency.

torque per motor $(T_M) = \dfrac{a R F_t}{\eta N}$

$$= \frac{0.4 \times 0.54 \times 60024.5}{4}$$

$$= 3241.3\ N\text{-}m$$

2016 Fall

6. a) A electrical train weighing 500 tonnes climbs up-gradient with G=8 and following speed time curve

i. Uniform acceleration of 2.5 km/hr-sec for 60 sec
ii. Constant speed for 5 min
iii. Coasting for 3 min
iv. Dynamic braking at 3km/h-sec to rest

The train resistance is 20N/tonne, rotational inertia effect 10% and combine efficiency of transmission and motor is 80%. Calculate specific energy consumptions.

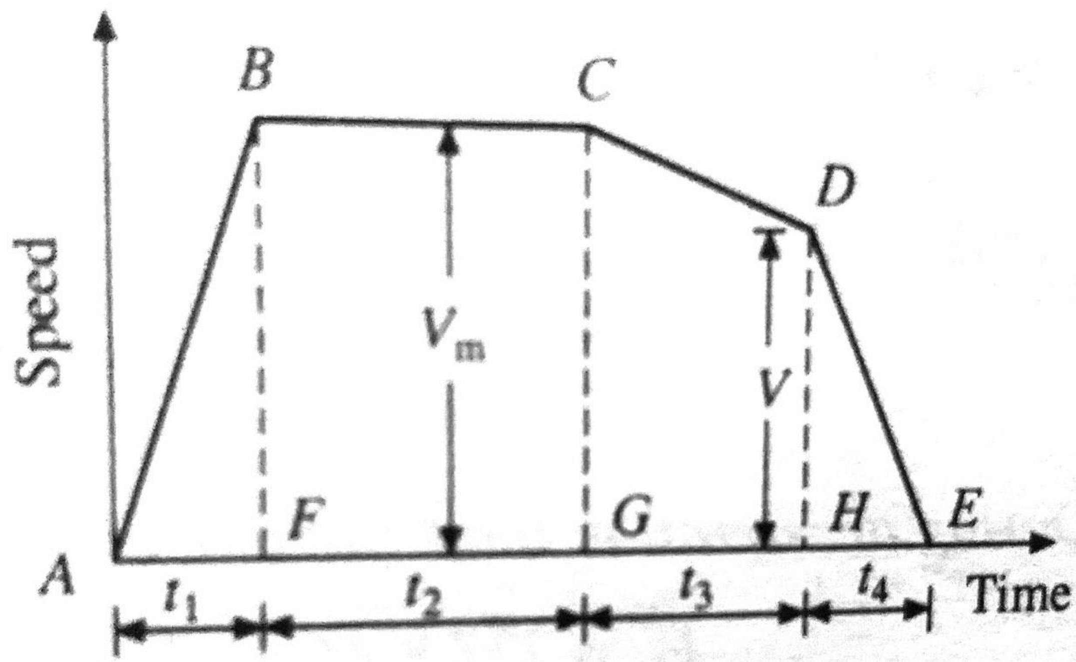

Fig. E.10.3

Solution

$$V_m = \alpha t_1 = 2.5 \times 60 = 150 \text{ kmph}$$

Retarding force during coasting

$$F_{CB} = F_g + F_r = 9.81\ MG + Mr$$

$$= 9.81 \times 500 \times 8 + 5000 \times 25 = 51740, \text{ N}$$

Deceleration during coasting

$$\beta_C = \frac{F_{CB}}{277.8 M_e} = \frac{51740}{277.8 \times 1.1 \times 500} = 0.3386$$

Speed after coasting $V = V_m - \beta_C t_3 = 150 - 0.3386 \times 180 = 89$ kmph

$$t_4 = \frac{V}{\beta} = \frac{89}{3} = 29.67, \text{ sec}$$

Distance covered during acceleration

$$= \text{Area ABF} = \frac{1}{2} V_m \frac{t_1}{3600} = \frac{1}{2} \times 150 \times \frac{60}{3600} = 1.25 \text{ km}$$

Distance covered during constant speed

$$= \text{Area FBCG} = 150 \times \frac{5}{60} = 12.5 \text{ km}$$

Distance covered during coasting

$$= \text{Area GCDH} = \frac{1}{2}(V_m + V) \times \frac{t_3}{3600}$$

$$= \frac{1}{2}(150 + 89) \times \frac{3}{60} = 5.975 \text{ km}$$

Distance covered during braking

$$= \text{Area HDE} = \frac{1}{2} V \frac{t_4}{3600} = \frac{1}{2} \times 89 \times \frac{29.67}{3600} = 0.367 \text{ km}$$

Distance between stops

$$D = 1.25 + 12.5 + 5.975 + 0.367 = 20.092 \text{ km}$$

$$D_1 = 1.25 + 12.5 = 13.75 \text{ km}$$

$$\frac{D_1}{D} = \frac{13.75}{20.092} = 0.684; \; 1 - \frac{D_1}{D} = 0.316$$

$$\text{Specific energy output} = \frac{0.01072\, V_{\mathrm{m}}^2}{D} \cdot \frac{M_{\mathrm{e}}}{M} + 2.725\, G \cdot \frac{D_1}{D} + 0.2778 r \cdot \frac{D_1}{D}$$

$$= \frac{0.01072(150)^2}{20.092} \times 1.1 + 2.725 \times 8 \times \frac{13.75}{20.092} + 0.2778 \times 25 \times \frac{13.75}{20.092}$$

$$= 13.205 + 14.919 + 4.753 = 32.877, \text{ Whptpkm}$$

$$\text{Specific energy consumption} = \frac{32.877}{0.8} = 41.1, \text{ Whptpkm}$$