Unit-V Other aspects of Electric traction

Service lines

Railways offers the following three types of passengers services -

(i) **City or urban :-**

In this types of service, there are frequent stops, the distance between stops being nearly one kilometer or less. Thus, in order to achieve moderately ~~hig~~ high schedule speed between statio it is essential to have high acceleration and retardation.

(ii) **Sub-urban services :-**

In this, the distance between stops average from 3-5 km over a distance of 25-30 km from the city terminus. In this case, also, high rates of acceleration and retardation is necessary.

(iii) **Main service lines :-**

In this, operation is over long routes and stops are infrequent. ~~He~~ Here, operating speed is high and acceleration and braking ~~p~~ period are relatively less important. There are three types of services available on good traffic side-

(a) Main-live freight services.

(b) Local or pick-up freight service.

(c) Shunting services.

Speed-time curve for train movement

The movement of train and their energy consumpt can be stuied by means of speed-time and speed-distance curves. As their names suggest former gives speed of train in various time after the start of the run and later gives speed at various distance ~~at~~ from starting point.

Out of two ~~te~~ speed time curve it is most important because of reasons -

- Its slope gives acceleration and retardation.
- Area between it and horizontal (time) axis represents the distance travelled
- Energy required for propulation can be calculate if resistance to motion is known.

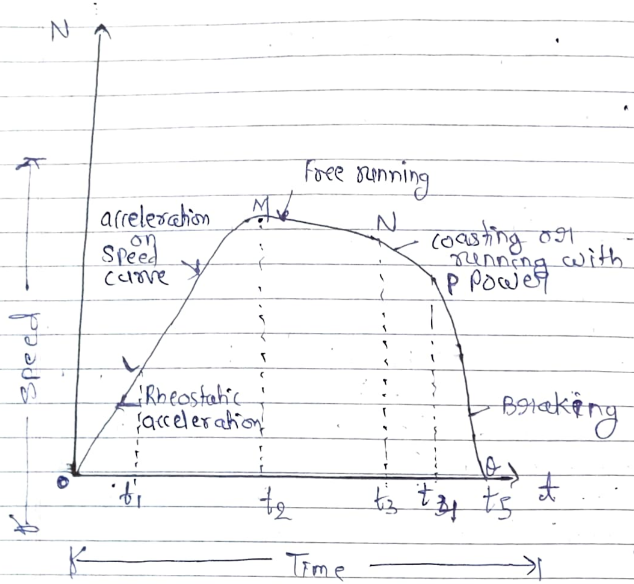

fig:- Speed-time curve of train.

The above figure shows a typical speed-time curve for electrical train operating on the passengers services. It mainly consists of following five parts:-

(A) Rheostatic or ~~contsatan~~ constant acceleration period.

(B) Acceleration on speed curve.

(C) Free running period.

(D) Coasting. or running with Power.

(E) Braking.

(A) **Rheostatic acceleration :-**

During this motors, the traction motors accelerates the current taken by motor and tractive efforts are practically constant.

(B) **Acceleration from speed curve ($t_1 - t_2$) :-**

After starting operation of motor is over, train still continues to accelerates along the curve LM. During this time interval, the motor current and torque decrease while the train speed starts increasing.

(C) **Free-running period :-**

It is time interval, that train attains its maximum speed at t_2 and remains nearly constant so as power is also constant.

(D) **Coasting:-**

The time period of ~~t~~ $t_3 - t_4$ known as Coasting. At end of free-running period the power supply is cut-off. and the train is made to run at its own momentum the speed of train starts decreasing on account of resistance to the motion of train. The rate of decreasing speed in the coasting period is known as coasting retardation.

It is desirable since, utilizes some of kinetic energy of train which would be wasted at braking. Hence, helps in reduce the energy consumption, represented by points NP in curve.

(E) **Braking:-**

In this time period, the brakes are applied and the train is brought to rest. It is represented by points PQ.

Speed-time curve for different services.

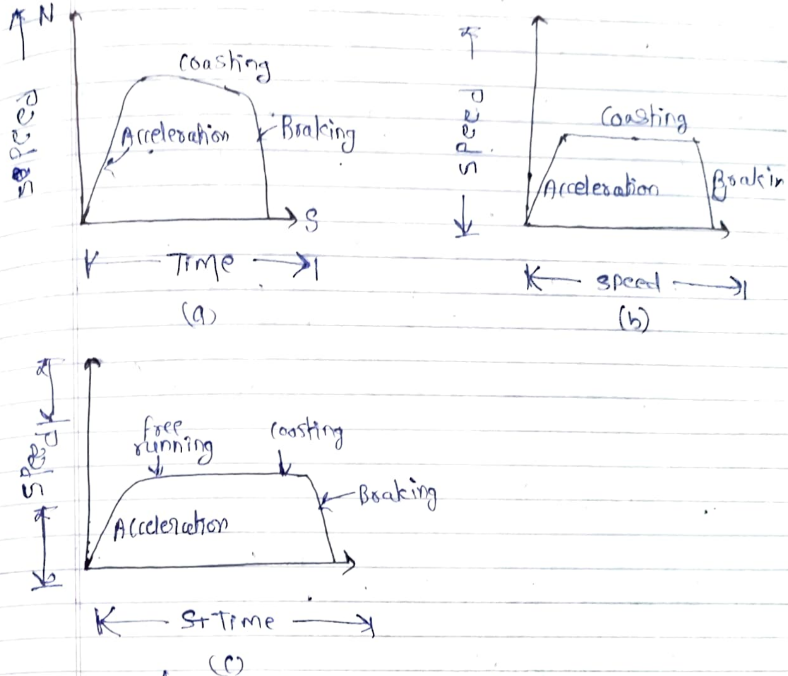

fig:- Speed-curves for different services.

- The above figure represents the city service (fig-a) where the acceleration and retardation is high in order to achieve moderately high average speed b/w stops. Due to short distance stopage, there is no possiblity of free-running state.

- In sub-urban service, (fig-b) there is no free-running as privious curve but it has comparatively longer coasting period because of variable distance b/w stops.

- In main-line service (fig-c), there is a long free-running period with high speed. In this, acceleration and retardation is relatively less important.

The acceleration and retardation of service system depends on fact that they should not create discomfort to the passengers.

Important terms of traction movement:-

(i) Crest speed:-

It is defined as maximum speed (V_m) attain by vehicle during the run.

(ii) Average speed:-

The ratio of distance covered between two stops and actual time of run is known as average speed, given by-

$$\text{Average speed} = \frac{\text{Distance b/w stops}}{\text{Total time of run}}$$

(iii) Schedule speed:-

It is defined as the ratio of the distance between two stops and total time of run includin the stopage time. It is denoted by V_{sch} given

$$V_{sch} = \frac{\text{Distance covered between stops}}{\text{Actual run time + stop time}}$$

Following are factors affecting schedule speed of a vehicle:-

- Acceleration and braking retardation.
- Maximum or crest speed.
- Duration of speed.

(iv) Specific energy consumption:-

It refers to an energy used per unit of work usually tonnes-kilometer. It represents the energy consumed by train to move a certain amount of weight over specific distance.

(v) Dead weight:-

It refers to a total weight of train including all components that need to be moved by the locomotives. It is the weight that train need to overcome for acceleration.

(vi) Accelerating weight :-

The total weight that train need to be accelerate, including rotational inertia, such as wheels or axle etc. It is essentially the combination of dead weight and weight appl by rotating parts needing to accelerate alon train.

(vii) Adhesive weight :-

The adhesive weight is the amount of weight carried on driving wheels of train. It is generally 20-40% of dead weight.

(viii) Coefficent of adhesive :-

The ratio of tractive effort to slip of wheel to the adhesive weight of train is known as coefficent of adhesive (μ_o).

$$\Rightarrow \mu_o = \frac{\text{Tractive effort to slip of wheel}}{\text{Adhesive weight}}$$

$$\Rightarrow \mu_o = \frac{F_t}{W_a}$$

$$\Rightarrow \text{or, } \mu_o W_a = F_t$$

$\Rightarrow$ $\boxed{F_t = \mu_o M g}$ where, $F_t = 9800\,\mu_o \times M$ Newton.

~~(ix)~~ (ix) Tractive effort :-

The force or effort produce between body and surface to produce motion, typically through friction. It is the force that vehicle uses to overcome resistance and move forward.

Simplified Speed-time curves

The curves of urban, sub-urban and main line is replaced by equivalent curves i.e the urban and sub-~~ur~~urban is replaced to the quadilateral speed-time curve whereas main line service curve is replaced by Trapezoidal speed-curve.

(i) Trapezoidal speed-time curve :-

Let :- D be distance b/w stops in meters.
t be actual time
α = acceleration during starting in m/s^2.
β = Retardation during braking in m/s^2.
V_m = Max. or crest speed.
V_a = Average speed.
t_1 = Time of acceleration
t_3 = Time of braking.
t_2 = Time of free-running.

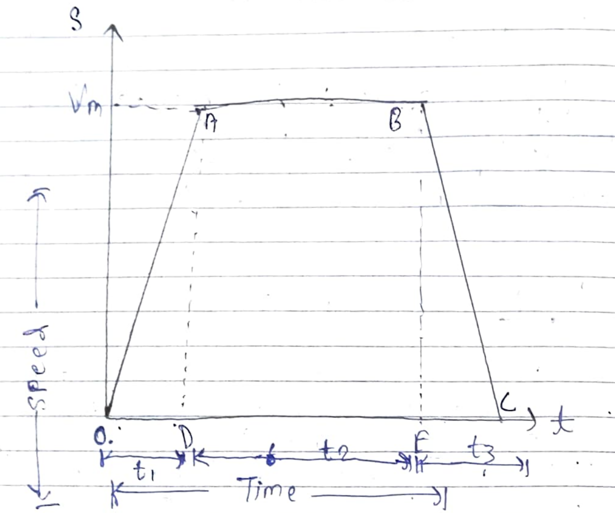

fig:- Trapezoidal speed-time curve.

From figure, Acceleration during starting -

$$\Rightarrow \alpha = \frac{V_m}{t_1}$$

$$\Rightarrow \text{or, } t_1 = \frac{V_m}{\alpha} \quad \text{---- eq}^n \text{ (i)}$$

Similarly, Acceleration during breaking -

$$\Rightarrow \beta = \frac{V_m}{t_3}$$

$$\Rightarrow t_3 = \frac{V_m}{\beta} \quad \text{---- eq}^n \text{ (iii)}$$

Now, Distance -

$\Rightarrow$ D = Area of trapezoid.

$\Rightarrow$ D = Area of ΔOAD + Area of $\square ABDE$ + Area of ΔBCE.

$$\Rightarrow D = \tfrac{1}{2} V_m t_1 + V_m t_2 + \tfrac{1}{2} V_m t_3$$

$$\Rightarrow D = \tfrac{1}{2} V_m \left(\frac{V_m}{\alpha}\right) + V_m[t-(t_1-t_3)] + \frac{1}{2} V_m \frac{V_m}{\beta}$$

$$\Rightarrow D = \frac{V_m^2}{2\alpha} + \frac{V_m^2}{2\beta} + [t-(t_1+t_3)]V_m.$$

$$\Rightarrow \boxed{D = \frac{V_m^2}{2}\left(\frac{1}{\alpha}+\frac{1}{\beta}\right) + [t-(t_1+t_3)]}$$