Electrical Traction

- It's the system in which electrical motors generates torque which is useful in pulling the locomotive/load connected to it
- Traction Effort should be maximum specially at the time of starting.
- equipment should be capable of handling overload for short period.
- Easy speed control - (DC easier).

Advantage

i) cleanliness

ii) high starting torque

iii) Flexibility of operation

iv) less Maintainance

v) cost is 50% less as compared to coal

vi) coefficient of adhesion is More (Between wheel & track)

vii) Power to weight ratio is more.

viii) Regerative Braking (80% of power is feedback to the line)

Disadv

i) High initial cost

ii) Power failure (2012-incident) due to frequency mismatch.

iii) extra circuitary for controlling

(iv) A.C (Interference near by communication line)

Types of Traction

Types of electrification system used in Traction

i) DC system (ii) 1φ AC low frequency

(iii) 3φ AC (iv) Composite → 1φ AC to DC, Kando system

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1) DC system

600 to 750 V – urban

1500 to 3000V – Mainline service

(eg. western Railway) Mumbai – ~~Ato~~

Current collection system in DC { Third rail system / Pentograph }

Their substation are automatic (or) remote controlling

disadv Initial cost of DC substation is high.

adv No interverence in DC system

(II) speed controlling is easier.

2 1ϕ low frequency AC (used outof India eg. west-Germany, Australia, USA)

- 1ϕ, 15KV, $16\frac{2}{3}$ cycle/sec. (Hz) – Australia & west Germany
- USA – 11KV, 25c/sec.
- $\downarrow X_L = 2\pi f L \downarrow$, P.F $\uparrow$, $\eta \uparrow$
- speed is controlled by varying the applied voltage.

3 3ϕ AC system

In this system 3ϕ Induction Motors operating a (3300 – 3600)V at normal frequency (or) $16\frac{2}{3}$ HZ are used. The distribution system consists of 2 overhead lines and track rail for the 3rd phase. and receives power either directly from the generating station (or) throw the ~~H/F~~ substation.

4. Composite system

1ϕ to 3ϕ system / KANDO system – 1ϕ HVAC system is employed for distribution purposes.

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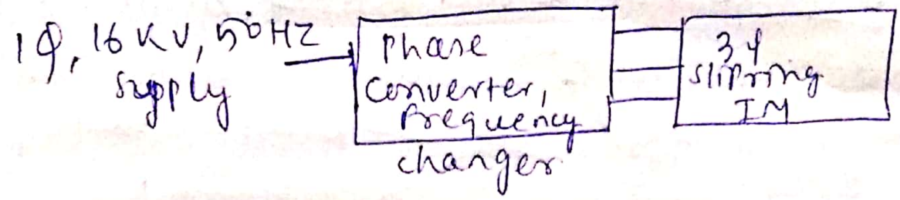
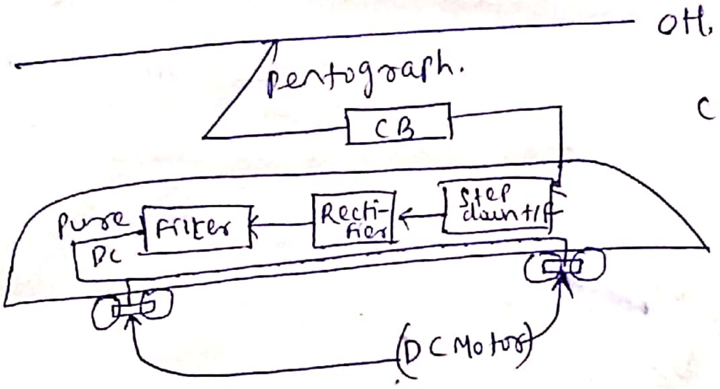


* Used in Hungary (central Europe)

* low cost, HF is not used,
low cost Because transformer's cost is much higher than phase converter. system.

1φ AC to DC (is used in Northern railway)



CB used is -
Air Break Circuit Breaker

Current collecting system

current from the overhead line is collected with the help of a collector fixed on the Roof of the vehicle

Types of collector

i) Trolley collector – Used for Tramways and Trolley Buses
(Suitable for low speed as 32kmph)
ii) Bow collector
iii) Pentograph.

(ii) Bow collector uses a metal light strip or Bough for current collection about one meter long

- Not suitable for railways (Requiring speed more than (20 KMPH)
- Requires a Reversing arrangement of Bow.

Disadv : complex

iii) Pentograph :- (1) Main fun^n is to maintain the link between overhead contact wire and the power ckt of the locomotive at various speed, in different climate and wind conditions.

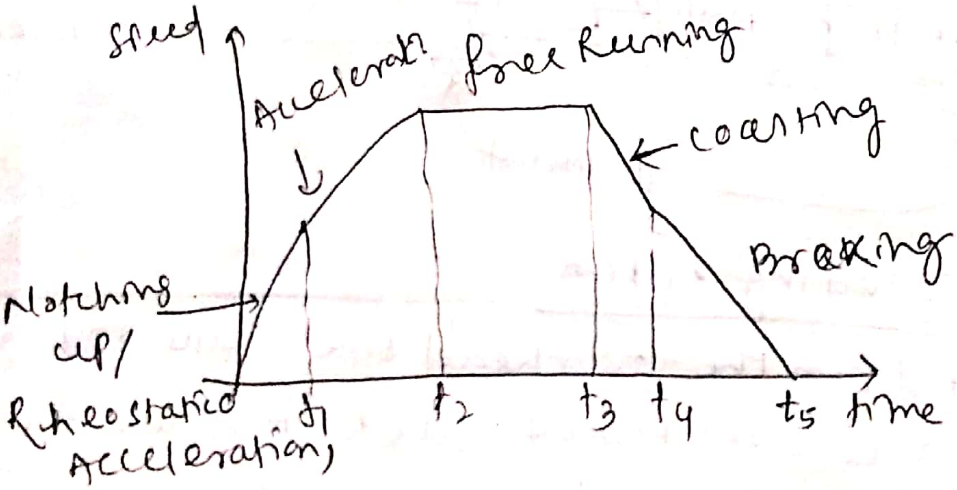
Pentograph is of 2 type — Diamond shaped
→ Cross arm type

Traction Mechanics

- Speed-distance curve
- Speed-time curve (Better)
  ↓
  Because the slope gives the acceleration & Area gives the distance

$$\text{slope} = \frac{\text{speed}}{\text{time}} = \text{Acceleration}$$

$$\text{speed} \times \text{time} = \text{distance}.$$



Rheostatic Accelerat^n – cut the starting Resistance of locomotive, here current fluctuate between minimum to max^m limit.

Nothing up – (0-t_1) – I fluctuate means tractive effort/ tractive force will fluctuate as F=BIL!!!
But Average current is same constant hence Tractive effort is constant.

2) Acc(t_1 - t_2) ⇒ starting Resistance cutout i.e. Full voltage supply voltage applied;

In DC series Motor: N speed ↑ → Torque ↓ → I ↓

($N \propto V$ (or) E_b)

N reaches to its maximum speed.

3) Free-running (t_2 - t_3) - constant 'N' at constant 'P'.

→ Coefficient of Adhesion is more

4) Coasting period :- desirable (voltage-off) electrical braking.

But the locomotive continues to run because of the kinetic energy present in wheel.

(5) Braking (t_4 - t_5) - Mechanical Brake.

* train brought to rest

Type of service

Parameters	Urban	Sub-urban	Mainline
1) Distance betn 2 station	1-2 Km	2 to 8 Km	More than 10 Km.
2) Acc in Km/hr (speed/sec) sec	1.5 to 4	1.5 to 4.	0.6 to 0.8 Km
3) Retardation in Km/hr/sec	3 to 4	3 to 4	1.5
4) Max. speed	120	120	160.

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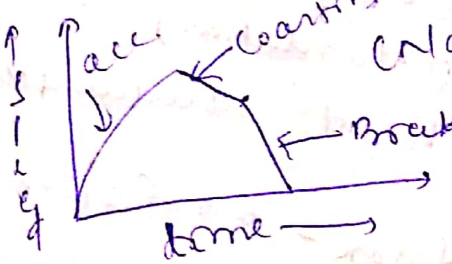
free running - acceleration is ~~goverarer~~ governed by speed-torque characteristics of motor.

* coasting & Braking depends upon train's Resistance, braking method & braking Retardation.

Speed - Time curve of urban

1)

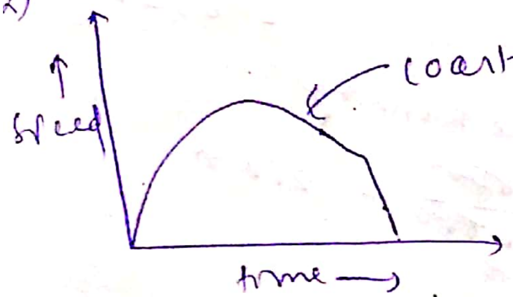


(No free Running period)

* No free Running coasting is small.

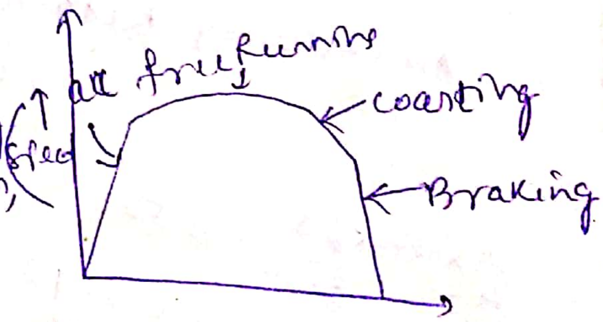
2) Suburban

* No/Negligible free Running but coasting is Large



3) Main line source

free Running & coasting is large & acceleration, and Braking is small.



(1) Max^m speed / Peak / crest

(2) Average speed = $\frac{\text{Distance b/w 2 stations}}{\text{actual time of run}}$

(3) Schedule speed = $\frac{\text{Distance betn 2 station}}{\text{Run time + stop time}}$

4) factors affecting scheduled speed

(1) Max^m speed → ↑ → Scheduled speed ↑

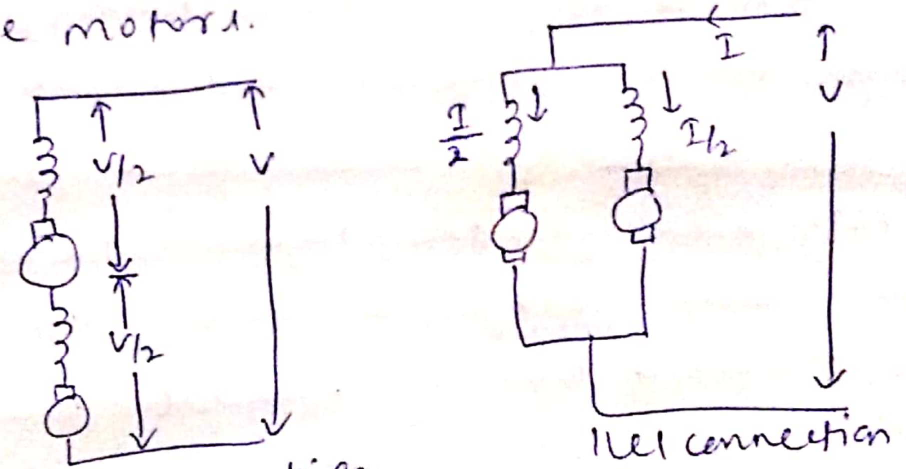
(2) acceleration → ↑ as speed in more → time ↓ scheduled speed ↑.

Control of Traction Motor

Rheostatic control – A series motor can be started by connecting an external resistance (starter) in series with the main ckt of the motor and as the motor speeds up, the external resistance is gradually reduced in order to maintain the current constant throughout the starting and accelerating period.

* loss of energy in the ~~energy~~ external ckt.

2. Series-llel control. The ~~draw~~ drawback of wastage of electrical energy in rheostatic control is partly overcome in this method when there are 2(or) more motors.



series connection

llel connection

whenever the series motors are connected in sequence (series) each and every armature of the motor receive the one half of the rated voltage. Thus the speed will be less.

- If the series motors are connected in llel each and every armature of the motor receives the full normal voltage and hence the speed is also high.

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Metadyne control

The metadyne control system is based on const. current system control. In metadyne control current throughout the accelerating period remains constant so the tractive effort developed is uniform and very smooth control without causing any wastage of energy in the starting resistance is achieved.

* **Braking**: Electrical and mechanical, both types of braking are used in electric traction. In electric braking energy is converted into electrical energy instead of converting it into heat energy at the brake shoes and either dissipated in the resistances mounted on the vehicle or return to the supply system.

→ Electric braking reduces the wear of the brake shoes and wheel tyres considerably and gives higher rate of braking retardation. thus brings the vehicle quickly to rest.

→ In case regenerative braking is employed. The braking energy is returned to the supply system thereby a considerable saving is affected in the running costs.

→ Electro-mechanical disk brakes operate via electrical actuation, but transmit torque mechanically when electricity is applied to the coil of the electromagnet, the magnetic flux attracts the armature to the face of the brake.

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