Unit-III Traction

Electric traction ~~drives~~

Electric traction refers to use of electric motors to provide the driving force for locomotion used in vehicles like trains, trams, trolley buss, and electric vehicles. Converting electrical energy to mechanical energy to propell them.

Requirements :-

- High starting torque produced.
- Low locomotive should be self started.
- Minimum wear and tear on track.
- Easy speed control.
- Pollution free, and high efficeny.
- sudden load bearing capacity. Regenerative braking is present.
- ~~lot~~ No communication interference on tracking system.
- Repairing and maintainance cost should be minimum. Smooth braking facility.

- There is possiblity to run at any route.

In this dC series motor, 1Φ ~~~~ AC motor and 3Φ induction motors are used to run the trains. Electricity is directly given to motor so that torque is sufficent to run the train.

Advantages:-

- In this system, acceleration, recordation, braking is high. So that ~~st~~ schedulity speed is high.
- It's running and maintainance cost is less (of 50%.)
- It does not emit ~~er~~ smoke or dust. due to which enviroment is clean.
- Due to regenerative braking, here less wear and tear problem.
- Railway electrification encourges rural electrification as no special transmission line to be run for this purpose.
- There is no vibration developed due to continous torque developed in electric motor.
- It Provide increased traffic handling capacity.

Disadvantages:-

- High intial cost of laying out overhead electrical Supply system. Unless, the traffic to be handled is heavy, electrical traction become uneconomical.
- Power failure for few minutes can cause traffic dislocation for hour.
- It is tied upto only electrified routes.
- Additional equipment is required for braking. In case of DC Series motor, regenerative braking is not a simple process.
- Communication lines which usually run parallel to the power supply lines suffer from electrical interference. Hence, This communication lines have either to remove away from the rail track or else underground cables have to be used for purpose. which makes the system still more expensive.
- In case electric traction provision of the negetive booster is essential. by avoiding the flow of return current through earth.

Traction motor

Traction motors are crusial in electrdchal traction have some of important features are as follows-

- **High efficency :-**

Traction motors are designed to maximize the conversion of electrical energy form battery into mechanical energy for better range of performani and efficency.

- **Rebust ~~comb~~ construction :-**

It is built to withstand harsh condition of Vehicle operation including vibration, temperature etc. It often featured to seal structure to prevent dust and moisture.

- **Braking system :-**

Traction motors acts as generators while brakin. converting mechanical energy back to electricity to change battery. This known as regenerative braking. It enhances efficency reduces wear durin the braking etc.

- **Specialised cooling system :-**

Due to involvement of high power level, it produ sufficent heat during operation. Thus, it requires an effective cooling system. Forced air, water or any special dielectric liquid is used commonly for cooling purposes.

- **Power Conversion :-**

Most of the traction motors operates on AC powe requiring an inverter to convert DC from battery Thus, an inverter play an important role in motor torque and speed. providing smooth and efficent operation.

- **Direct torque control :-**

Direct torque Control (DTC) is a motor control metho that directly controls the motor torque and flux enables fast and smooth motor control.

Railway-track electrification

- A track electrification involves the usage of electrical power instead of diesel power achieve by stalling overhead lines along a track, allowing trains to draw power for operation.

- It draws power from corresponding lines of grid using pentograph, It is directly transmitted from power plants to rails and the distributed to trains.

The track electrification is of following types-

(i) DC system.

(ii) 1ϕ AC system

(iii) ~~ϕ~~ 3ϕ AC system

(iv) Composite ~~sty~~ system.

(i) DC system:-

In DC system, the electrical motors employed for getting the necessary motion power are usually DC series motor. Althouses, compound motors are coming in favour of trams and ~~tralt~~ tralley buses. where regenerative braking is desired.

DC current at 600V to 750V is universally employed for tramways in urban areas and for ~~more~~ many suburban railways while 1500-3000 V DC is used for main-line railways. These substation are automatic and remote controlled, dc supply so obtained is fed via suitable contact system. to the traction motors which are either DC series motor for electric locomotive or compound motors for tramway and trawlley buses. where regenerative braking is required.

Advantages:-

- When operating under similar conditions DC train consume less energy, 1ϕ AC trains.

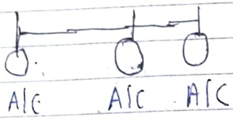
- No interference with overhead communication. lines.

- Equipments of DC train is lighter, less costly, and more efficent that similar AC equipment.

• For frequent and rapid acceleration of heavy trains DC motors are better suited than A.C. motor

Disadvantages:-

The main disadvantage of DC system is the necessity of locating AC to DC converting Substations at relatively short distance apart. It increases the maintainance costs.



(ii) Single Phase system :-

In this system, AC series motors are used for getting necessary motive power.

(iii) 3ϕ AC system :-

In this system, the required motion power is obtained by the use of 3ϕ induction motors operating at 3.3-3.6 KV, 16.2/3 Hz frequency. Substation receive power at a very high voltage from 3ϕ transmission lines at the usual industrial frequency of 50Hz. The high voltage is step-down to 3.3KV or so by transformers whereas frequency is reduced from 50 Hz to 16.2/3 Hz frequency by frequency converters installed at substation.

3ϕ induction motors employed in this system are quite simple and robust and give trouble-free operation.

Uses:-

These system is used in some hilly areas where output power required is high and regenration on large scale is possible.

(iv) Composite system :-

It is of two types-

(a) 1ϕ to 3ϕ system or Kando system :-

This system consist of 16KV - 50Hz, 1ϕ overhead Supply being converted into 3ϕ supply by means of phase convertor equipment carried on locomotive

This 3ϕ supply is fed to 3ϕ induction motor

Advantages:-

The advantage of this system is that complicated overhead trawlley wire equipment of ordinary 3ϕ system is replaced by a single wire system by using SCR as inverter.
It is possible to get variable frequency 3ϕ supply at 1/2 - 9 Hz frequency, at this low frequency, 3ϕ motors develop high starting torque without taking excessive current. There exists good possiblity of these traction system to develop for farther adaption.

(ii) 1ϕ - AC to DC system:-

In this system, it employes overhead 1ϕ - 25 KV, 50 Hz supply which is step-down by the transformer in the locomotive. This 1ϕ supply is then converted into DC and used in driving dc series motor. This system has been adopted for all future track electrification in India.

Advantages:-

- High starting efficency.
- Simplicity of substation design.
- Less no. of substation.
- Lower cost of fixed installation.
- Live overhead catenary.

Disadvantages:-

- 1ϕ - AC system produces both current and voltage unbalancing effect on supply.
- It produces interference in telecommunication circuit.

Comparison on AC and DC traction -

S.no	Point of Comparison	DC traction system	AC traction system
1.	Efficency	more efficent	less efficent
2.	Cost	Cheaper	Expensive
3.	Maintainance required	Less	more
4.	Speed control	Limited speed control	Wide range of Speed control
5.	Acceleration	High	low
6.	Torque	Less torque	High torque.

7.	Energy consumption	less	more
8.	Capital cost of substation.	more	less
9.	Regenerative braking	More efficent	less efficent

Collector - Gear for overhead equipment (current collector)

The primary requirement of a collector is that it should maintain a continous contact with trawlley wire at all speeds. There are three types of commonly used gear are -

(i) Trawlley connector.

(ii) Bow collector.

(iii) Pentograph.

(i) Trawlley collector / Pole ~~whole~~ collector :-

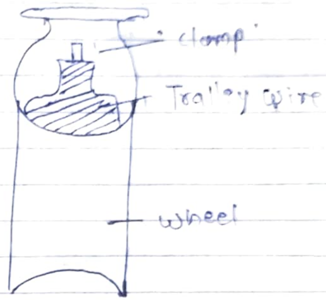


fig:- Tralley collector.

Tralley collector is used in tramways and tralley buses and is mounted on the roof the vehicle. A contact with the overhead wire is made by means of either a grooved wheel on a sliding shoes on

and held in contact with overhead wire by means of ~~screen~~ spring. The pole is hinched to a sweting base so that it may be reversed for reversed running ~~thereby~~. Trolley collectors always operate in the trailing position. It ~~was~~ employed upto speed of 32 km/h. Beyond this speed there is every possiblity of wheel jumping of the tralley wire.

(ii) Bow collector :-

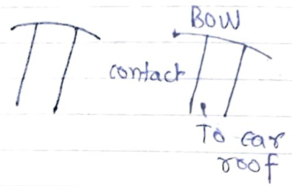


fig:- Bow collector.

It consists of light metal strip or baw (about 1m) brassing against tralley wire (for collection of current) and the framework is mounted on the roof of car. The strip is made of soft materi (i.e copper, aluminium or carbon). There is no possiblity of strip jumping of the tralley wire.
It also operates at trailing position so it require provision of either duplicate bow or an arrangement for running at reverse direction.
It is often used at high speed but not be capable to use in railway at speed above 120 km/h.

(iii) Pentograph :-

A pentograph collector maintains connection between overhead wire and power circuit of locomotives at different speeds under all operating conditions and stiffness of equipment.

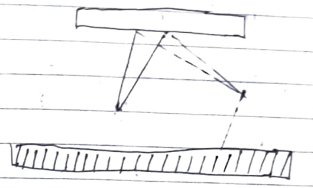


fig:- Pentograph collector

This necessititates the positive pressure is maintain at all the time to avoid loss of contact or sparking but minimise pressure to reduce wear of overhead line. It is mounted on pentagonal framework of high tensile alloy-steel tubing, which can raised or ~~a~~ lowered ~~to~~ by compressing air. It can be employed in railways as capable of running over 120-150 km/h.

Electrical braking

The ~~mod~~ most simple way to stop any motor used in locomotives is electrical supply disconnection to terminals. There is no longer torque develop and the combined effects of rotor and the load is works to bring it at rest.

When any rapid and more positive action is required, mechanical or electrical braking may be employed but, electrical braking has many serious advantages over mechanical braking.

Basic requirements:-

The electrical braking systems require the follow basic requirements —

- **Reliability:**

  the braking system should be reliable and consistently reproduced braking effect.

- **Speed :-**

  The braking speed should be quick and ~~starts~~ applied immediate deceleration to avoid any chances of accidents.

- **Energy dessipation:-**

  The system designed such that it safely dissipates the kinetic energy of rotating parts of motor.

- **Emergency stop:-**

  In case of failure, the system must be able to bring machine or vehicle to a complete stop.

Salient features:-

The electric braking system consists of the follow salient features —

- **Smooth and Precise speed control:-**

  It allows for very fine adjustment to speed, making it ideal for applications requiring precise control. These control ~~speep~~ speed continously unlike mechanical brakes have binary ON/OFF rate.

- **Quick response time:-**

  The system reacts instantaneous to change in the speed or load, providing immediate deceleration. This was not offered to mechanical brakes.

- **Minimal mechanical wear & maintainance:-**

Electrical brake rely on electrical signals and magnetic flux to control breaking, thus provide reduced wear & tear and maintaince as compar to mechanical brakes.

- **Versatility:-**

It is can be adapted to different motor type and applications including DC, AC or electric Vehicles.

- **Low environmental impacts:-**

Since, it doesn't contain any type of flue gases or noise so it doesn't have any major enviromental impact.

Advantages:-

- Electrical braking is smooth.
- It is more economical then mechanical braking.
- In mechanical breaking, due to excessive bear on brake drum, linear etc. It ~~read~~ needs frequent and costly replacement.
- In regenerative braking, electrical energy can returned back to supply which is not possible in mechanical braking.
- By employing electrical braking the capacity of the system can be incrcased by way of higher speed and ~~haulak~~ haulage of heavy loads.
- In mechanical braking, the heat is produced at brake linear or brake drum which may be source of failure of brake. In electrical braking the heat is produced at convenient place which is noway is harmful to a braking system.

Disadvantages:-

- Since, the motor has to function as a generator during braking period therefore, it must have suitable braking characteristics i.e ~~to~~ choice of motor is limited.

- Additional complications, high initial cost, special motors, ~~which~~ capable of generating spei electrical energy, electrical braking costier.

Types:-

(i) Electrical braking.
(a) plugging
(b) Rheostatic or dynamic braking.
(c) Regenerative braking.
(d) Electromagnetic braking.
(e) Eddy current braking.

(ii) Mechanical Braking
(a) pneumatic braking
(b) Vacuum braking
(c) Electro pneumatic braking.
(d) Disc braking.

(iii) Hydraulic braking.

(a) Plugging:-

This method of braking involves reconnection of motor to supply in such away that motor now develops torque in opposite direction to the movement of rotor. System speed will decrease till zero speed is reached and then it will accelerates in opposite direction. Therefore, it become necessary to disconnect the supply as soon as system comes to rest.

This method is most inefficent, ~~Hence~~ has not only the kinetic energy of the moving masses is wasted. But, it requires additional energy from supply for the development of counter torque.

(ii) Regenrative braking:-

In regenerative braking motor is not disconnected from supply, but is made to run as a generator by utilising of kinetic energy of moving brake. Electrical energy is fed ~~bo~~ back to the supply. The ~~mat~~ magnetic drag producet on account of generator action offers the braking torque.

It is most efficent method of braking, reduce energy consumption and less wear and tear of brake locs. blocs, wheel and ~~trat~~ track, consequently, less maintainance required by these items. Relatively small amount of brake block dust formed which increases the life of bearings is and safe with which heavy load can be hauled. High value of brake retardation is obtained so that the vehicle can be brought quickly and running time is considerablely reduced. It provide high speed while going down the gradients.

There are some disadvantages as increased capital cost as motors of heavier size are employed. Additional cost on control equipment with consequent complication in methods of operation and control. Mechanical braking required at speed of 6.5Km/h to bring locomotive to rest.

(iii) Rheostatic braking :-

~~Rheos~~ During Rheostatic braking motor is made to work as generator and all the kinetic energy of the moving masses is converted to electrical energy which is dissipated in resistance connected as it electrical load.

In traction work, when two or three series motors are used, these motors are connected in parallel across a resistance. The kinetic energy (K.E) of the vehicle is used in driving motors as generators which dissipates this energy in the form of heat in rheostat to which they are connected.

- **Equilizer connection :-**

The two machines in parallel, amount to two series generators in parallel and in order that they may self excited, an equizer connection is shown in figure-1 has to be used. If these connection is not used, the machine that would send a current through the other in opposite direction with the result, that the second machine would excite with reverse voltage. The two machines would be short circuited on themselves and might even burnt out on account of large currents. The equilizer prevent such a condition.

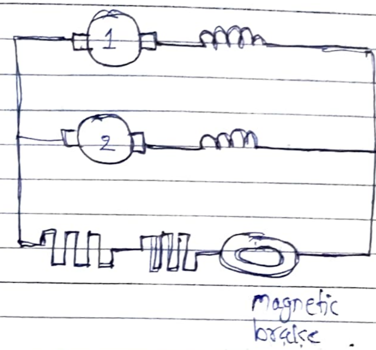


fig-1 Equilizer connection.

- **Cross Connection :-**

Another alternative method of avoiding the above mention situation is cross connecting field of two machines as shown in figure-2.

Suppose the voltage of machine-1 is greater than that of machine 2. It will send a greater current through field of machine-2, causing it to excite to a higher voltage and its own excitation is kept down because of lesser induced emf. of machine-2. Thus, automatic compensation is provided and the two machines undergoes ~~sta~~ satisfactory operation.

The second method is advantageous to first one. since, if direction of rotation of armature reverses due to run back, the machines fails to excite in first method. and no braking effect can be produced but with cross-connected field the machine build up in series since they are S.C upon themselves, they provide emergency braking and would not allow the car to run back on a gradient.

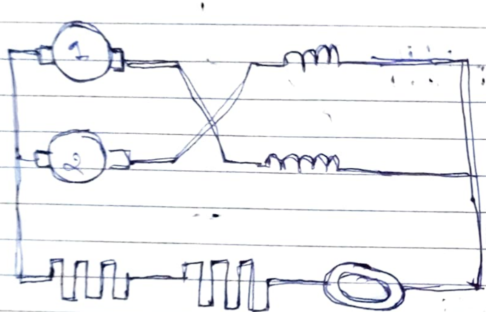


Fig:- Cross-connected system.

Advantages:-

- Reduced energy consumption.
- Less wear and tear of brake ~~bra~~ block, wheel ... consequently, less maintainance required by ...
- Relatively small amount of brake-block dust formed which increase the life bearings.
- Ease and safety with which heavy load loads can be hauld over stiff gradients.
- Higher value of braking retardation is obtained so that the vehicle can be brought to rest quickly and running time is considerably reduced.
- High speeds are possibles while going down the gradients.

Disadvantages:-

- Increased capital cost as motors of heavier size are employed.
- Additional cost on control equipment with consequent complication in method of operation. and control.
- Mechanical braking at speed of 6.5 km/h. to bring the locomotive to rest.