TYPES OF ELECTRIC TRACTION

Types of Electric Traction – The electric traction system maybe divided into two groups:

- The group consisting of vehicles which receive electric power from a distribution network fed at suitable points from either a central power station or substations suitably spaced. It is further subdivided into
    1) Systems operating with d.c. such as trolley buses, tramways and railways.
    2) Systems operating with a.c. such as railways.
- The group consists of self contained locomotives i.e. they generate their own power. It is further subdivided into
    1) Diesel electric trains and ships
    2) Petrol electric trucks and lorries
    3) Battery driven road vehicles

Tramways – The tram car is supplied electricity by grooved wheel or bow from a single overhead conductor at 600 V d.c. fed at suitable points from a central power station or substations. There are at least two driving axles which enable the tram car to be started from any one end. This enables series parallel method of speed control to be applied. The overhead conductor is of positive polarity and the track rail forms the return conductor. For suburban services, higher speeds are achieved by using field weakening method of motors. The motors are provided with ventilating ducts placed in the top half of motor frame in such a way that rainwater of track is not splashed into the motors. The fig.1 shows a schematic dig. of tramways. This system of traction is now losing ground to trolley bus or I.C. engined omnibus system due to the following reasons:

1) It needs laying down of overhead supply systems and tracks for which results in heavy expenditure and becomes a source of danger for other road users since the tracks carry return currents.
2) There is lack of flexibility of operation in areas of heavy congestion and noise.

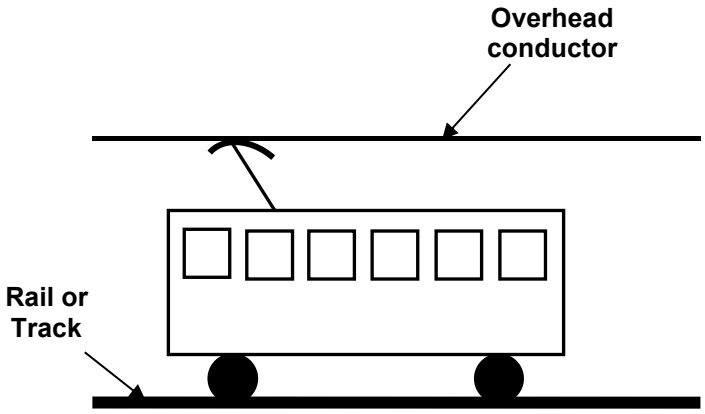

Fig.1

For very dense traffic in large cities the tramway is most economical means of transportation. The life of tram car equipment is much more than that of internal combustion engine omnibus. The conditions for regenerative braking are not very favourable but it may be used in hilly areas and on level track upto a speed of 20 kmph. Rheostatic and mechanical brakings are employed for normal service, mechanical braking is employed when the speed becomes too low that electrical braking becomes ineffective. For mechanical braking, electro-mechanical drum brakes are employed. Magnetic brakes are employed for providing better retardation. The magnetic brakes are in fact electro-magnets suspended on springs. These are attracted to rail track, where they exert sufficient braking force. Thus dual braking effect is obtained. Tram cars if provided with magnetic brakes can be excited by the rheostatic braking current.

Trolley Bus – The serious drawback of tramway is the lack of manoeuvrability in congested areas and noise. These are overcome by trolley bus system of traction. In this system the vehicle is similar to omnibus having rubber tyres and powered by electric motor.

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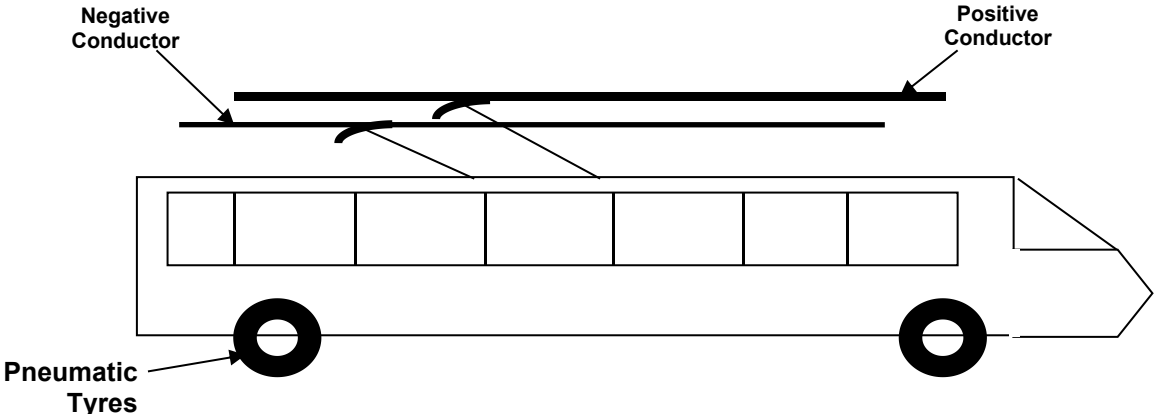
Since there is no track as in the case of tramways, there are two overhead trolley wires operating at 600 V d.c. supply. The supply to the traction motors is fed through the two overhead contact wires by means of two collectors as shown in fig.2 Due to higher coefficient of adhesion between rubber tyred wheel and road than that in the case of tram car, it is possible in this case to employ single axle drive without running the risk of slip.



The motors employed are generally 80 to 150 H.P. (or 50 to 100 kW) compound wound motors where speed control can be carried out by inserting resistance in the shunt field or using diverter across series field. The master controllers are foot operated so the driver should have his hands free to steer the vehicle. One pedal controls the starting, speed control and regenerative braking if any and second pedal controls rheostatic braking. Although the overhead equipment required by the trolley buses is more expensive and more unsightly than that for the tram, this drawback is usually more than offset by the elimination of the necessity of the track in the road way, which is costly to maintain and also constitutes a source of danger to the other road users.

Another advantage of trolley bus is that it is able to manoeuvre in traffic over a width of several meters on each side of the centre line of the trolley wires. Speed control is obtained by field weakening (by providing a resistance in the shunt field or the tappings on series field or divertors with the series field) method. The lighting system in the car is low voltage dc supplied from a motor generator set connected in parallel with a battery. The vehicles are usually provided with secondary batteries so that the vehicles can be manoeuvred in case of emergency. As the body of the vehicle is insulated from earth because of tyred wheels, care must be taken to ensure adequate insulation resistance. The insulation resistance is checked at the end of the day when it is hot and damp therefore, in its worst condition. The trolley bus can accommodate slightly more passengers than oil engined bus. Due to high acceleration and braking retardation, it has got a higher schedule speed over a given route than the oil engined bus; hence fewer trolley buses will be required for operating a given service. Trolley buses are used for the inner suburbs with medium traffic density. Although oil-engined buses are more expensive to maintain and operate than a trolley bus, urban and rural services operating with a service interval of more than 15 or 20 minutes are more expensive to operate through trolley wire system due to too large relative cost of overhead equipment.

Diesel Electric Traction – It is the dominant type of locomotive in the world today. But what does the term "Diesel-Electric" really mean? There have been five major types of locomotives used in the history of railroads;

1. Steam Locomotive
2. Electric Locomotive
3. Diesel (or gas) Torque-Converter Locomotive
4. Turbine Electric Locomotive
5. Diesel Electric Locomotive

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A steam locomotive burns coal or oil, converting water into steam, and then uses the steam to drive pistons, which are connected by drive rods to the wheels. A straight electric locomotive, on the other hand, uses electricity provided by an overhead wire or "3rd rail" next to the tracks, to power electric motors (known as "traction motors") that are geared directly to its wheels. The diesel or gas torque-converter locomotive uses some kind of internal combustion engine which is geared directly to the drive wheels using a "torque converter", more commonly known as a "clutch". The disadvantages of this arrangement are many, as burning out a clutch 200 miles from the maintenance base would present obvious problems. The turbine-electric, is also one of the rarest types. The diesel electric locomotive uses a diesel engine to drive an electric generator, which then supplies the current to traction motors, which are geared directly to the locomotive's wheels.

In India, the diesel locomotives were introduced in 1945 for shunting purposes on broad gauge section and in 1956 for main line services on medium gauge section. The diesel electric locomotives employed in practice are of the following types:

1. Main line diesel electric locomotive having engines of output not exceeding 1500 kW and speeds of 160 kmph.
2. Shunting diesel electric locomotive having an engine of 225 to 375 kW output and speed between 25 to 50 kmph.
3. Diesel electric multiple units stock of which each motor has an engine of 135 to 150 kW output and train is capable of having speeds between 80 to 110 kmph.
4. Diesel electric rail car having an engine of 75 to 450 kW output which may operate as a single car or car with one or more trailer coaches.

In diesel electric system used for traction, electric motors are used for driving the locomotive which are fed by a d.c. generator driven by diesel engine mounted on the same locomotive as shown by the schematic diagram in fig.1

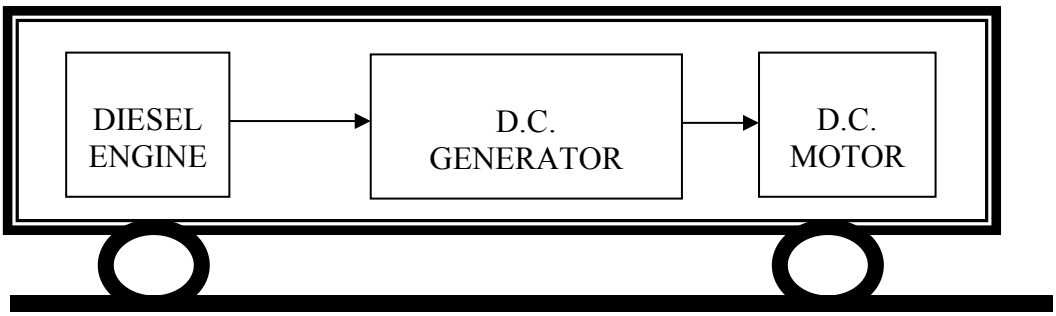
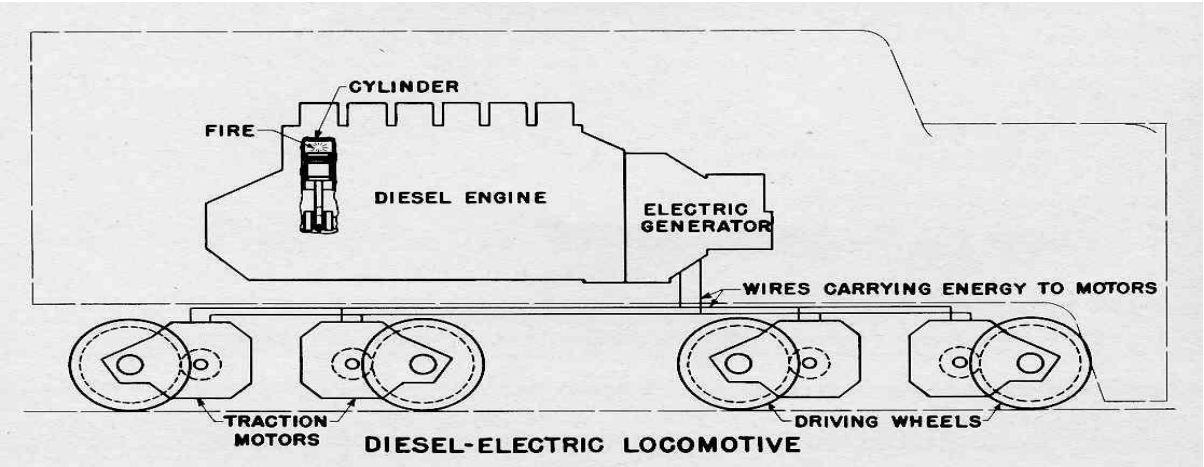


Fig.1

The following figure shows a diesel electric locomotive:



Advantages – The following are the advantages of diesel electric traction:

1) The conversion from steam engine traction to diesel electric traction does not requires any modification of the existing tracks.
2) The initial investment required is low as compared to direct electric traction since there is no need of overhead structure distribution system and equipments.
3) Due to its higher acceleration and retardation, the schedule speed over a given route will be higher resulting in accommodation of more passengers as compared to steam locomotive. This results in fewer locomotives to be required for operating a given service.
4) It is available for hauling for almost 6 and a half days in a week for 24 hours duty due to less time spent in maintenance.
5) It has got a higher haulage capacity as compared with a steam locomotive.
6) It can be put into service at any moment since hardly any time is required to start up the engine and put it on duty.
7) The power loss in speed control is very low because it can be carried out by field control of generator.
8) Its overall efficiency is higher than that of steam locomotive about 25%.
9) There is no interference with the adjoining communication lines.
10) One of the main advantages of this arrangement is that, since the engine is not directly attached to the wheels, starting a heavy train cannot "stall" the engine, as in the case of the I.C. engine locomotive.
11) Since a diesel electric locomotive is a self contained unit and does not requires any overhead structure hence it can be used on any route.

Disadvantages – The following are the disadvantages of diesel electric traction:

1) Its overload capacity is limited.
2) The life of the diesel engine is comparatively shorter.
3) In addition to motor generator set, special cooling system is required for cooling the diesel engine also.
4) Its running and maintenance costs are high.
5) It requires more axles as its dead weight is more compared to the electric locomotive.
6) For the same power output, diesel electric locomotive is costlier than steam or electric locomotive.
7) Regenerative braking cannot be used with such types of drives.

Electric Locomotive – It is the most widely used traction system in which the vehicle draws electrical energy from a distribution system fed at suitable points from a central power station or substation. In India both AC and DC type of electrified train systems operate today. 1500 V DC based train system is mostly operating in Mumbai area. It is being converted to 25 kV AC system. Rest of the India where routes are electrified mostly operates under 25 kV AC overhead wire. As of 2006, Indian railways haul 60% of freight and 50% of passenger traffic with electric locomotives. The electric locomotives are of two types

- A.C. locomotive
- D.C. locomotive

In case of d.c. locomotive d.c. motors are used for traction. The fig.3 shows a schematic block diagram of d.c. locomotive.

TYPES OF ELECTRIC TRACTION

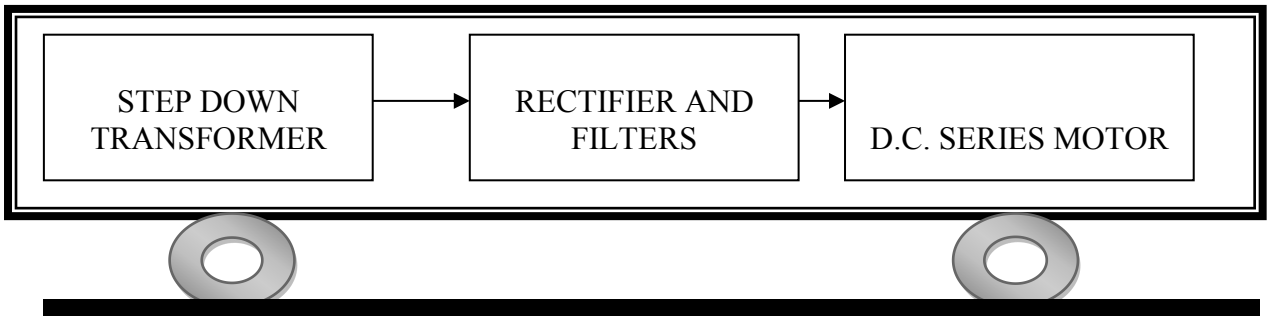


Fig.3

It basically consists of a step down transformer, a full wave rectifier with filters and d.c. motors. The fig.4 shows an a.c. type electric locomotive. The following are the advantages and disadvantages of electric system:

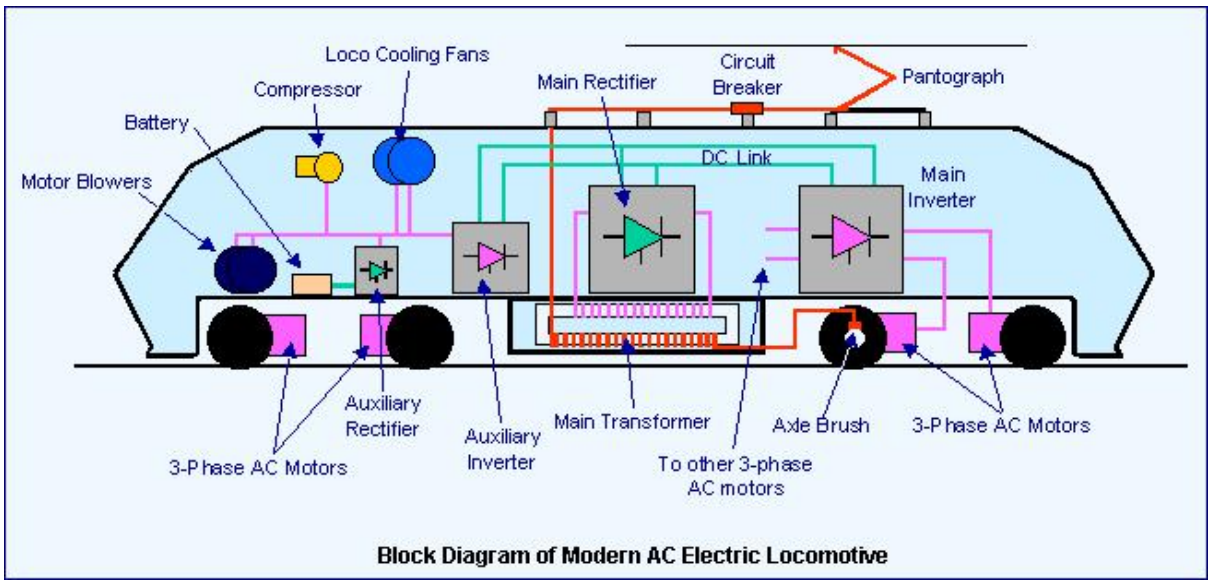


Fig.4

Advantages

1) It is the cleanest of all other types of systems of traction as it has no smoke and due to this only it is ideally suited for underground and tube railways.
2) It does not requires any water and coaling depots or diesel depots en route like in case of steam traction and diesel electric traction.
3) The size of the running sheds and workshops is comparatively smaller since no ancillary equipments are required.
4) Due to high starting torque it is possible to achieve high acceleration rates of 1.5 to 2.5 kmphps as against 0.6 to 0.8 kmphps in case of steam engine drive which results in high schedule speed and almost double traffic handling capacity as compared to steam locomotive.
5) It can be divided and run in sections during the period of light traffic thus enabling a frequent service to be maintained.
6) Due to absence of unbalanced forces produced by reciprocating masses, coefficient of adhesion is more in the case of electric traction as well as riding quality is better , less wear and tear of track occurs as compared to steam locomotive.
7) It requires less terminal space for operating a given service due to speedy movement and lesser number of units required.
8) An electric locomotive requires much less time for maintenance and repairs than a steam locomotive; and hence can be kept in service for 95% or more of the working day if desired.
9) Its maintenance and repair cost is about 50 % of that of steam locomotive.

10) The electric locomotive can be put into service immediately whereas steam locomotive requires about two hours getting up steam and be ready for service.
11) The centre of gravity of electric locomotive is lower than that of steam locomotive due to which it is able to negotiate curves at comparatively higher speeds.
12) The vibrations in electric locomotive are less as the torque exerted by the electric motor is continuous.
13) Electric braking is used in this case which is superior to mechanical braking used by steam and diesel locomotives. It is possible to apply regenerative braking which has the following advantages
    - Above 80% of energy spent during ascent is pumped back during descent.
    - Goods traffic on gradients is more safe and speedy
    - Less maintenance of brake shoes, wheels, tyres and rails on account of less wear and tear.
14) Slow speeds on steep gradients at the time of descent is possible due to better braking control since in case of steam locomotives brake blocks and wheels are likely to overheat reducing the braking power.

Disadvantages

1) The most important factor against electric traction is high capital outlay on overhead supply system. Therefore, unless heavy traffic is to be handled electric traction becomes uneconomical.
2) Power failure for few minutes can cause disruption of traffic for hours.
3) A number of severe statutory regulations concerning leakage currents from overhead conductors and the voltage drop in track rails have to be complied with.
4) The electric traction system is tied to electric routes only. Hence it cannot be used on any of the routes.
5) In case of A.C. traction the communication lines running along the track experience considerable interference from power lines. The communication lines therefore must either be removed away from the track or replaced by special expensive cables (this increases the capital cost outlay by 15%)
6) In cold countries where snowfall is there for most of the period during the year, a service locomotive is required to run up and down the line to prevent formation of layer of ice on the conductor rails.
7) If the provision of negative booster is not made, return current through earth causes lot of corrosion of underground pipe work and interference with telegraph and telephone work.
8) In cold climates the steam locomotive can conveniently use its steam for heating the compartment of train cheaply whereas the electric train has to do it an extra cost.