Unit -4 Electric Traction

Question Bank

1. Explain speed time curve for different services of electric traction.
2. Describe the requirements of ideal traction systems.
3. Explain in detail special features of traction motors.
4. Explain in detail the mechanics of train movement.
5. What are the track electrification system? Explain any one detail.
6. A train weighing 120 tonnes is to be driven up an incline of 2 percent at a speed of 36 kmph. If the train resistance at this speed is 2kg per tonne. Find the current required at 1500 V dc if the efficiency of the motors and gearing is 88%. If the current were cut-off how long world the train take to come to rest.
7. An electric train weighing 200 tonnes has eight motors geared to driving wheels, each wheel is 90cm diameter. Determine the torque developed by each motor to accelerate the train to a speed of 48 kmph in 30 seconds up a gradient of 1 in 200. The tractive resistance is of 50N per tonne, the effect of rotational inertia is 10% of the train weight. The gear ratio is 4 to 1 and gearing efficiency is 80%.

Explain Different Types of Traction System

Traction system:
Classification Based on Electrical Power drive:
(i) Non-Electrical Traction
(ii) Electrical Traction

Non-Electrical Traction: Traction system which does not uses the electrical power to drive, are called Non-Electrical Traction system.
there are various types of non-electrical systems:

- Steam Engine
- Diesel Engine

Electrical Traction (System of Railway Electrification): Traction system which uses the electrical power to drive, are called Electrical Traction system. There are 4 types of electrical systems:

- D.C. System
- Single Phase A.C. System
- Three Phase A.C. System
- Composite System

D.C. system: D.C. system contains D.C. supply of rating 600V, 750V, 1500V, and 3000V.
dc system uses the low voltage, series wound D.C. Series Motor to drive the train. dc motor is well suited to railroad traction, being simple to construct and control. Until the late 20th century it was universally employed in traction system.

Single Phase A.C. System: Alternating current system was used due to incapability of DC system i.e. high voltage. The higher voltage limit for the DC system was 3000 Volts. With alternating current, especially with relatively high voltage over-head wire, fewer substations are required, and the lighter overhead current supply wire that can be used correspondingly reduces the weight of structure needed to support it to the further benefit of capital cost of electrification.
single phase 16 *(2/3) Hz and 25 Hz frequency of supply is used in single phase ac system .
A.C. series motor is used due to high starting torque. Substations are used in distance of 30-40 Km to maintain the voltage level along the track. Voltage rating is 15-25 KV for this system.

Three Phase A.C. System: This system is used for high voltage ratings. In three phase system we can transmit high voltage level which is for efficient transmission is required.
This system uses 3 phase induction motor, 3 3-phase supply, 50-60 Hz supply.
voltage rating of motor is 3.3-3.5 KV.

Composite System: There are two types of composite systems.

- single phase to DC system
- single phase to 3 phase system

The first one single phase of the DC system is used where voltage level is high for transmission and dc machine is used in the locomotive.
single phase to 3 phase system is used where 3 phase machine is used in the locomotive and single phase track we have.

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The requirements of ideal traction systems:

Ideal traction system should have capability of developing high tractive effort in order to have rapid acceleration

1. The speed control of the traction motors should be easv
2. Vehicles should be able to run on anv route, without interruption
3. Equipment required for traction systems should be minimum with high efficiency
4. It must be free from smoke, ash, dust, etc.
5. Regenerative braking should be possible, and braking should be in such a way to
6. cause minimum wear on the brake shoe
7. Locomotive should be self-contained, and it must be capable of withstanding
8. overloads
9. Interference to the communication lines should be eliminated while the locomotive
10. running along the track
11. High efficiency
12. Low initial as well as maintenance cost

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Comparison between AC Traction and DC Traction Systems

The following table compares and contrasts the various features of AC and DC traction systems −

Point of Comparison	DC Traction System	AC Traction System
Efficiency	DC traction system is more efficient.	AC traction system is less efficient.
Cost of motor	DC series motors are cheaper.	AC motors are expensive.
Maintenance	DC traction system requires less maintenance.	AC traction system needs more maintenance.
Speed control	The speed control of DC series motor is limited.	With the AC motors, wide range of speed control is possible.
Cost of system	The overall cost of the DC traction system is less.	The overall cost of the AC traction is more.
Overhead distribution	In DC traction system, overhead distribution of electrical power is possible.	In the AC traction system, overhead distribution is used.
Acceleration	DC traction system is capable of giving high acceleration.	AC traction system gives less acceleration.
Torque	DC series motor produces less torque.	The starting and running torque developed by AC motors is more.
Regenerative braking	DC series motors have more efficient regenerative braking.	In case of AC motors, the regenerative braking is less efficient.
Interference with communication lines	DC traction system causes less interference with the communication lines.	AC traction system produces more interference with communication lines.
Number of substations	DC traction system requires more number of substations for a given track distance.	AC traction system requires less number of substations for a given track distance.
Suitability	DC traction system is suitable for urban line railway service.	AC traction system is suitable for main line railway service.
Energy consumption	Energy consumption in DC traction system is less.	For same output, energy consumed by AC traction system is more.

Weight of locomotive	Weight of DC locomotive is less.	Weight of AC locomotive is more.
Capital cost of substation	For DC traction system, the capital cost of substation is more due to converting equipment.	Capital cost of AC substation is less.
Cost of conductor	In DC traction system, the cost of overhead conductor is more as the operating voltages are low.	AC traction system uses higher voltages so the cost of conductor is reduced.

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Track Equipment and Current Collecting system

A. Electric Locomotive:

Construction of electric locomotive is described below

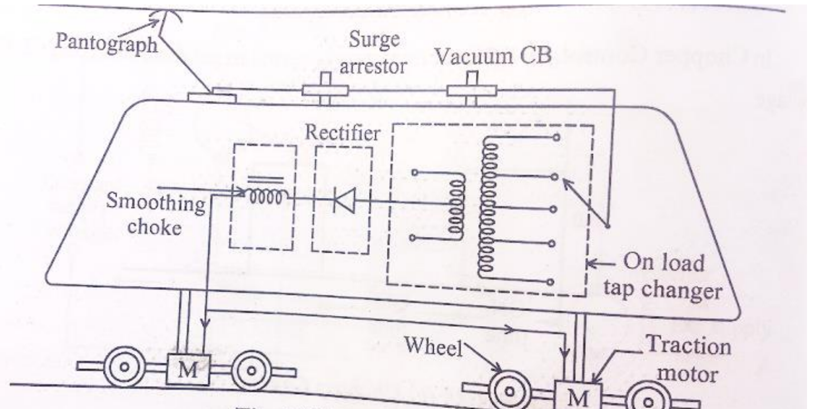

Fig. 1.30 Electric Locomotive

Electric locomotive consists of

1) Current collectors
2) Surge arrestor
3) Vacuum circuit Braker
4) On-load tap changer
5) Rectifier
6) Smoothing choke
7) Traction motor
8) Auxiliary System
9) ARNO converter
10) Protective equipments

1) Current collectors

It is device which is used to current collection from overhead wire. It remains in sliding contact with overhead wire at all speeds. Structure is made of high tensile alloys steel tubing and can be raised or lowered using compressed air or springs.

2) Surge arrestor

It is used to bypass surges from OHE to ground.

3) Vacuum circuit Breaker

It is mounted on the rooftop of the locomotive. It consists of a vacuum bottle having a fixed and a movable contact separated by a small distance as shown in Fig .1.31. When CB is closed, the two constacts – fixed and movable contact touch each other inside the bottle and current from pantograph is conveyed to the tap changing transformer. When power supply need to be switched off, the CB is opened so that fixed and moving contacts inside the vacuum bottle separate thereby interrupting the circuit. The vacuum between fixed and moving constant acts as arc quenching medium. When contacts begin to separate, an arc is formed. This is quenched by the vacuum medium. The CB apart from normal switch on and off operation, also operates under some abnormal condition thereby protecting downstream equipments.

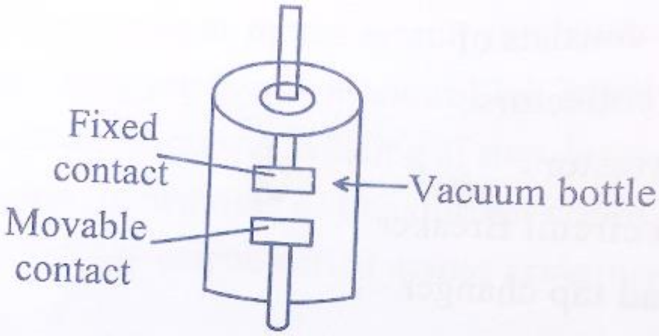

Fig. 1.31 Basic Vacuum Circuit Breaker

4) On-load tap changer

It is a transformer fitted with on-load lap changer. It is housed inside the locomotive cabin. 25 kV A.C power is stepped down to 1500 V by means of taps. Speed is controlled by on-load changer. The transformer winding is divided into 32 steps. With first step corresponding to 0 volts and 32 step corresponding to 1500V. The voltage output o transformer can be progressively increased to control speed. However, in thyristor controlled AC locomotives, there is no need or tap changers and rectifiers. Voltage is regulated by changing firing angle of thyristors.

5) Rectifier

It converts input AC voltage into DC output voltage. It provides full wave rectifier to DC series motor.

6) Smoothing choke

It removes ripples from rectifier DC output and feeds to DC traction motor.

7) Traction motor

It is DC series motor which provides motive power to wheels. Each axle of coach is driven by an individual traction motor.

8) Auxiliary System

In order to keep size of locomotives small, it is necessary to keep size of transforms rectifier and traction motor small. This is possible by blowing air through them to keep temperature within limits. So number of blowers for traction motor transformer and rectifiers are provided. A compressor is also provided for supplying air required for braking of locomotive and or operation of pneumatically controlled equipment. (raising or lowering of pantograph) These auxiliary machines are providedwith 3ϕ AC motors.

9) ARNO converter

Supply fed to locomotive is single phase, 25 kV where as requirement for auxiliary machines is 3-phase 400 Volts. So a winding is provided in transformer to step down 25 kV to 400 V. This single phase 400 V is converted to 3-phase supply by a rotating machine called ARNO converter.

10) Protective equipments

In electric locomotives, protection is needed for operating personnel against contact with live circuit and safety of individual equipments against major damage due to a fault.

B. Current Collection System

The primary requirement of a collection system is that it should maintain a continuous contact with wire at all speed. There are mainly two current collection system namely current collection from conductor rail and current collection from Over Head Equipment (OHE).

B.1.Conductor Rail System

This conductor – rail system of supply has been used in many countries, or electric traction. In this system, the current is supplied to the electrically operated vehicle through one – rail conductor or through two – rail conductors.

Depending on the positions of the contact surface, the conductor rail may be divided into three classes: Top, Bottom and Side.

The top rail is adopted universally for 600V DC electrification.

The side contact rail is used for 1200 V DC supply.

The bottom contact rail has the advantage of being protected from show, sheet and ice.

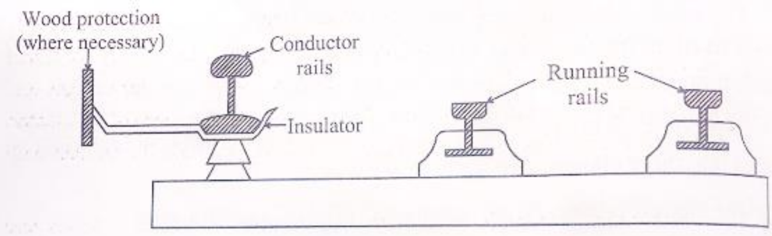

Fig. 1.32 Conductor – Rail System

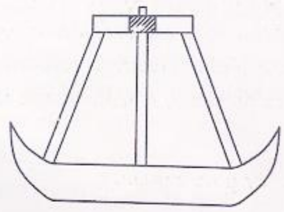

Fig. 1.33 Current Collecting Shoe

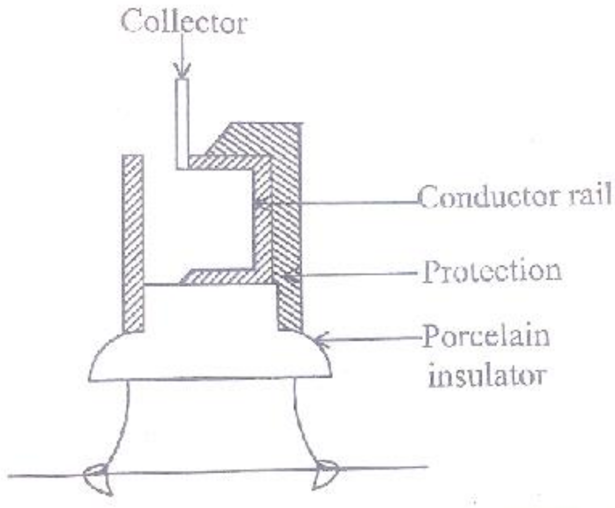

Fig. 1.34 Conductor rail with side running cost.

B.2. Current Collection Gear for Over Head Equipment (OHE)

Main requirement of a collection gear is that it should under no circumstances leave the contact of OHE. Contact wire in all practical installations is never perfectly horizontal. It raises and falls depending upon the weight of the contact wire, and distance between droopers. Also contact wire comes very low under bridge and tunnels and rises high over public crossing. Depending upon the speed of the electric vehicle, collection gear has to raise and fall in order to maintain the contact with OHE.

The over head system used with D.C. tramways, trolley – buses and locomotives and also with AC. Locomotives. The track is used as the return conductor. The voltage in the overhead system is 600 V and above. The various material used for the overhead wire are hard drawn copper, cadmium-copper or silicon – bronze. Although of higher electrical resistance due to the higher tensile strength and wear resistance property, silicon-bronze is mostly used. Three types commonly used gear are:

1. Trolley collector or pole collector
2. Bow collector and
3. Pantograph collector

Trolley collector or pole collector

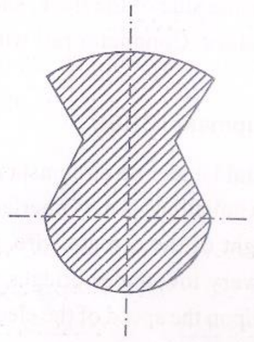

Fig. 1.35 Trolley cross – section

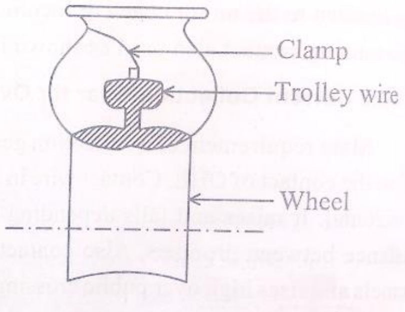

Fig. 1.36 Collector wheel and Trolley wire

Bow collector

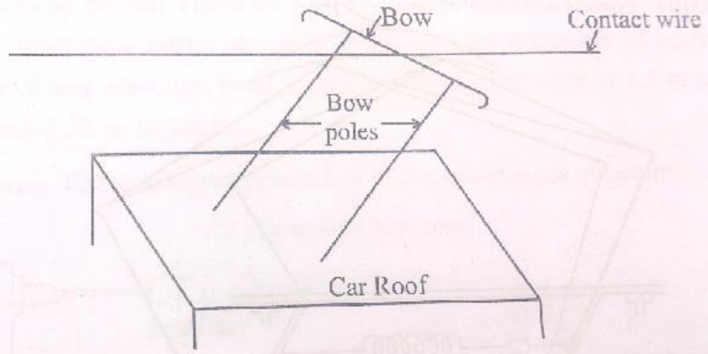

Fig. 1.37 The Bow collector

Pantograph collector

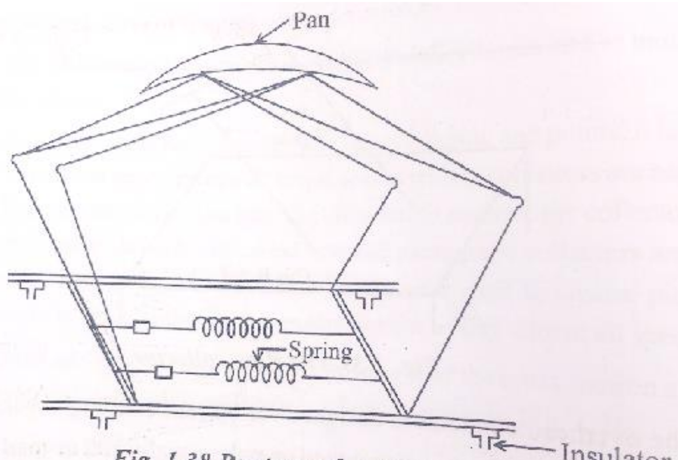

Fig. 1.38 Pantograph collector