ELECTRIC TRACTION(CH.06)

Electric Traction Systems:-

The system which use electrical power for traction system i.e. for railways, trams, trolleys, etc. is called electrical traction. The track electrification refers to the type of source supply system that is used while powering the electric locomotive systems. It can be AC or DC or a composite supply.

Selecting the type of electrification depends on several factors like availability of supply, type of an application area, or on the services like urban, suburban and main line services, etc.

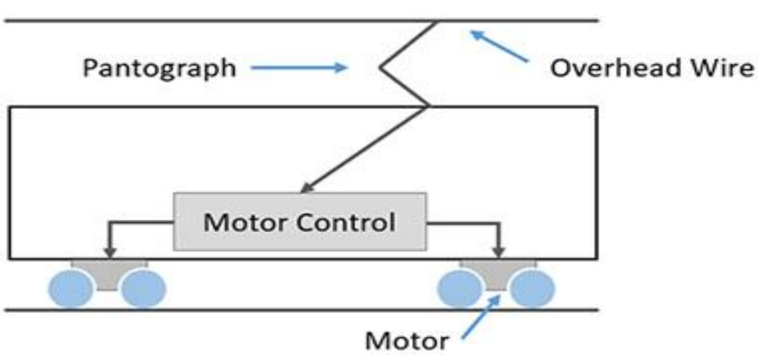
The three main types of electric traction systems that exist are as follows:

1. Direct Current (DC) electrification system
2. Alternating Current (AC) electrification system
3. Composite system.

1- DC Electrification System

The choice of selecting DC electrification system encompasses many advantages, such as space and weight considerations, rapid acceleration and braking of DC electric motors, less cost compared to AC systems, less energy consumption and so on.

In this type of system, three-phase power received from the power grids is de-escalated to low voltage and converted into DC by the rectifiers and power-electronic converters.



This type of DC supply is supplied to the vehicle through two different ways:

a. 3rd and 4 the rail system operate at low voltages (600-1200V)
b. Overhead rail systems use high voltages (1500-3000V)

The supply systems of DC electrification include;

a. 300-500V supply for the special systems like battery systems.
b. 600-1200V for urban railways like tramways and light metro trains.
c. 1500-3000V for suburban and mainline services like light metros and heavy metro trains.

Due to high starting torque and moderate speed control, the DC series motors are extensively employed in the DC traction systems. They provide high torque at low speeds and low torque at high speeds.

Advantages;

a. In case of heavy trains that require frequent and rapid accelerations, DC traction motors are better choice as compared AC motors.
b. DC train consumes less energy compared to AC unit for operating same service conditions.
c. The equipment in DC traction system is less costly, lighter and more efficient than AC traction system.
d. It causes no electrical interference with nearby communication lines.

Disadvantages;

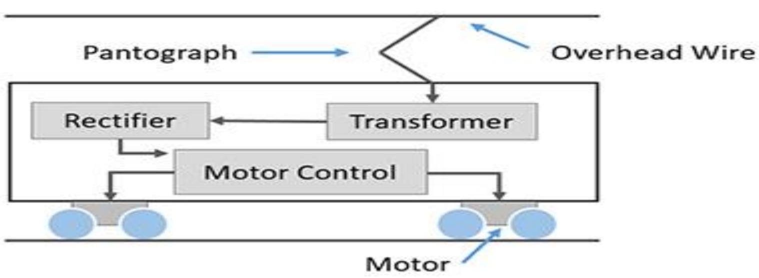
1. Expensive substations are required at frequent intervals.
2. The overhead wire or third rail must be relatively large and heavy.
3. Voltage goes on decreasing with increase in length.

2- AC Electrification System

An AC traction system has become very popular nowadays, and it is more often used in most of the traction systems due to several advantages, such as quick availability and generation of AC that can be easily stepped up or down, easy controlling of AC motors, less number of substations requirement, and the presence of light overhead catenaries that transfer low currents at high voltages, and so on.

The supply systems of AC electrification include single, three phase, and composite systems. The Single phase systems consist of 11 to 15 KV supply at 16.7Hz, and 25Hz to facilitate variable speed to AC commutation motors. It uses step down transformer and frequency converters to convert from the high voltages and fixed industrial frequency.

The Single phase 25KV at 50Hz is the most commonly used configuration for AC electrification. It is used for heavy haul systems and main line services since it doesn't require frequency conversion. This is one of the widely used types of composite systems wherein the supply is converted to DC to drive DC traction motors.



Three phase system uses three phase induction motor to drive the locomotive, and it is rated at 3.3.KV, 16.7Hz. The high-voltage distribution system at 50 Hz supply is converted to this electric motor rating by transformers and frequency converters. This system employs two overhead lines, and the track rail forms another phase, but this raises many problems at crossings and junctions.

Advantages;

1. Fewer substations are required.
2. Lighter overhead current supply wire can be used.
3. Reduced weight of support structure.
4. Reduced capital cost of electrification.

Disadvantages;

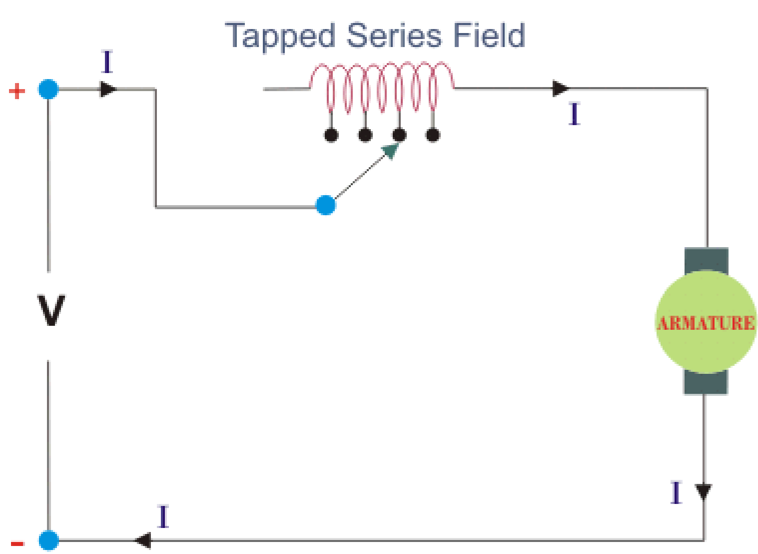
1. Significant cost of electrification.
2. Increased maintainance cost of lines.
3. Overhead wires further limit clearance in tunnels.
4. Upgrading needs additional cost especially in case there are brigdes and tunnels.
5. Railway traction needs immune power with no cuts.

3- Composite System

Composite System (or multi-system) trains are used to provide continuous journeys along routes that are electrified using more than one system. One way to accomplish this is by changing locomotives at the switching stations. These stations have overhead wires that can be switched from one voltage to another. Another way is to use multi-system locomotives that can operate under several different voltages and current types. In Europe, it is common to use four-system locomotives. (1.5 kV DC, 3 kV DC, 15 kV 16⅔ Hz AC, 25 kV 50 Hz AC).

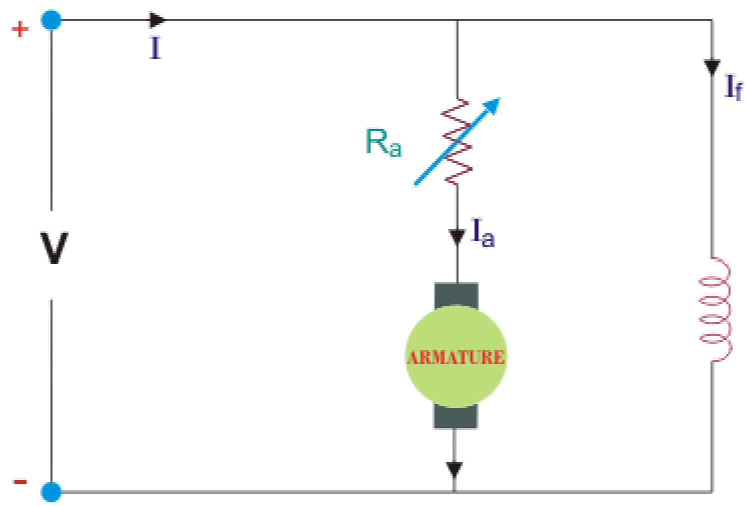
Tapped Field Control

This is another method of increasing the speed by reducing the flux and it is done by lowering number of turns of field winding through which current flows. In this method a number of tapping from field winding are brought outside. This method is employed in electric traction.

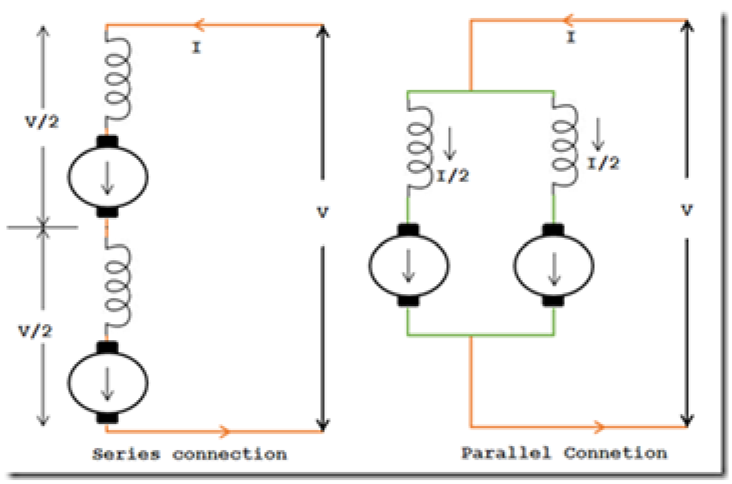


Rheostat Controlled Motor:-

In this method, speed variation is accomplished by means of a variable resistance inserted in series with the shunt field. An increase in controlling resistances reduces the field current with a reduction in flux and an increase in speed. This method of speed control is independent of load on the motor. Power wasted in controlling resistance is very less as field current is a small value.



Series Parallel control motor:-

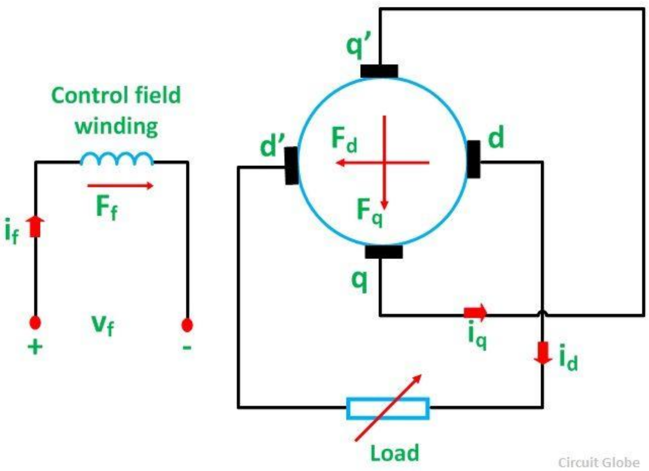


To control the DC series motor this is another way called series parallel technique. This is the method normally used in traction by connecting two or more than that of the series motor are couple mechanically at the same load.

Whenever the series motors are connected in sequence (series) like shown in the figure, 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 parallel, each and every armature of the motor receives the full normal voltage and hence the speed is also high. Thus we can achieve the two speeds (low or high) by connecting the motor either in series or parallel. Note for the same load on the pair of motors, the speed of the system would run nearly 4 times once motors are in parallel as while they are in series

Metadyne control motor:-

This speed control system is based on constant current system . in this system metadyne converter is used which takes power at constant voltage & variable current & delivers the same at constant current & variable voltage . In series parallel control or resistance control system there is waste of electrical energy in the starting resistance & the jerks are also experienced when the controller of the starter moves on notches. In metadyne speed control since current throughout the starting period remains constant .

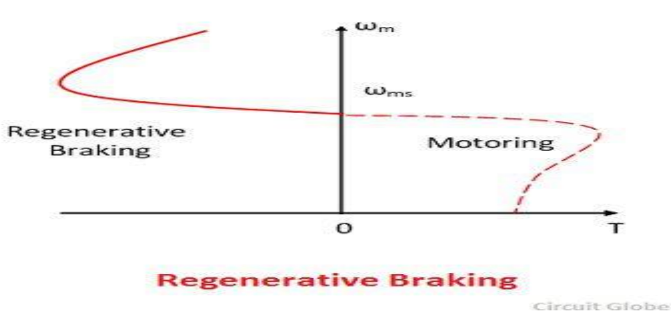


Regenerative braking:-

The input power of the induction motor drive is given by the formula shown below

$$P_{in} = 3VI_s cos\emptyset_s$$

Where φ_s is the phase angle between stator phase voltage and the stator phase current I_s. For motoring operation, the phase angle is always less than the 90º. If the rotor speed becomes greater than synchronous speed, then the relative speed between the rotor conductor and air gap rotating field reverse.



Magnetic Braking:-

The subject of magnetic braking is rarely discussed in introductory physics texts. To calculate the magnetic drag force on a moving metal object is generally difficult and implies solving Maxwell's equations in time-dependent situation. This may be one of the reasons why the phenomenon of magnetic braking, although conceptually simple to understand, has not attracted the attention of textbooks authors. A simple approximate treatment is however possible in some special cases. In our seminar we will try to explain magnetic braking with the understandable (simple) theory. Reports in literature have made the theory behind this phenomenon easily accessible. First we will be interested in the braking of a rectangular sheet moving linearly through the magnet.

2. 1 Magnetic braking of a rectangular sheet moving linearly through the magnet

A good source for explaining why this braking happens we find in [2]. We assume that the speed of the sheet is sufficiently small that the magnetic field generated by the induced current is negligible in comparison with the applied magnetic filed. Under this condition just stated, the magnetic drag force is seen to arise from mutual coupling between the induced current and the applied magnetic field.

When the metal plate enters the magnetic field, a Lorentz force

F q(*v B*)

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is exerted on the conduction of electrons in the metal. Here, *v*

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is the velocity vector of the

charge *q*, and *B*

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is the magnetic field vector. The force on the electrons induces a current in

the metal (eddy current). An induced current moves along a closed path as if induced by an electromotive force. Figure 1 shows these eddy currents in relation to the metal plate which moves perpendicular to the magnetic field.

Figure 1: Induced currents in the metal plate [2].

We use Faraday's law, which says that the magnitude of the induced emf is equal to the time rate of change of the magnetic flux,

B dS v(*B L*).

dt

d

dt

d

U_i

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A horizontal magnetic force is exerted on the portion of the eddy current that is within the magnetic field. This force is transmitted to the metal sheet, and is the retarding force associated with the braking:

F IL B,

where I is the current and L is the vertical height of the magnetic field.
Like we said when the metal sheet passes between the poles of the magnet, circulating currents (eddy currents) are generated. As a result, a magnetic breaking force is induced on the eddy currents which opposes the motion of the sheet. This is a simple theory of magnetic braking, which assumes that the magnetic field generated by the induced current is negligible in comparison with the applied magnetic filed. But we would like to have a theory, which does not assume that the magnetic field generated by the induced current is negligible.
In next sections of our seminar equations for a magnetic drag force and a magnetic lift force (a magnetic drag force acts together with a magnetic lift force) on a magnetic dipole moving over a nonmagnetic conducting plane are shown.

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