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DEPARTMENT OF ELECTRICAL ENGINEERING

SYSTEM OF TRACTION

- **Traction system**
- **Requirements of an ideal traction system**
- **Different systems of traction**
- **System of Track electrification**
- **Train Movement & Energy Consumption-Typical Speed /Time Curves**
- **Mechanics of Train Movement**
- **Power & Energy output from the driving axles**
- **Specific Energy consumption & Factors affecting Specific Energy consumption**

Traction system

- Act of drawing or state of being drawn propulsion of vehicle is called traction There are various systems of traction prevailing in our country such as steam engine drive, electric drive. These systems of tractions may be classified broadly into groups namely
- The traction system which do not involve the use of electricity at any stage and called as **non-electric tractions system** such as steam engine drive, IC engine drive etc.
- The tractions system which involves the use of electricity at some stage and other stage is called as **electric tractions**. System such a diesel electric drive, electric drive etc.

These are further classified into two groups

Self contained vehicles or locomotives eg Battery electric drive, Diesel electric drive
Vehicles which receive electric power from a distribution network eg
Railway electric motive fed from ac supply
Tramways and trolley buses supplied with DC supply

Requirements of an ideal traction system

1. High starting tractive effort in order to have rapid acceleration
2. Self contained& compact locomotive so that it may be able to run on any route
3. Equipment capable of withstanding large temporary overloads
4. Minimum wear on the track
5. Braking should be such that minimum wear is caused on the brake shoes, and if possible the energy should be regenerated and returned to the supply during braking period
6. Equipment required should be minimum of high efficiency and low initial & maintenance cost
7. No interference with communication lines (telephone & telegraph lines) running along the track
8. Easy speed control
9. It should be pollution free

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System of Track electrification

The way of giving the power supply to locomotive unit is generally referred as traction electrification system. Presently, there are four types of track electrification systems are available based on the availability of supply. These are

1. DC traction system
2. Single phase AC traction system
3. Three phase AC traction system
4. Composite traction system

DC traction system

- In this traction system, electrical motors are operates on DC supply to produce necessary movement of the vehicle. Mostly DC series motors are used in this system. For trolley buses and tramways, DC compound motors are used where regenerative braking is required.
- The various operating voltages of DC traction system include 600V, 750 V, 1500V and 3000V.
- DC supply at 600-750V is universally employed for tramways and light metros in urban areas and for many suburban areas. This supply is obtained from a third rail or conductor rail, which involves very large currents.
- DC supply at 1500- 3000 is used for main line services such as light and heavy metros. This supply is drawn mostly from an overhead line system that involves small currents.
- In both cases, only one conductor or rail is required to supply power to locomotive while track rails are used as return conductors in majority of cases.

Advantages of this system include:

- In case of heavy trains that require frequent and rapid accelerations, DC traction motors are better choice as compared AC motors.
- DC train consumes less energy compared to AC unit for operating same service conditions.
- The equipment in DC traction system is less costly, lighter and more efficient than AC traction system.
- It causes no electrical interference with nearby communication lines.
- Despite all these advantages, DC electrical system necessitates AC to DC conversion substations relatively at very short distances. This is the main disadvantage of DC traction system.
- That's why this system is preferred only for suburban and road transport services wherein stops are frequent and also distance between stops is small.

Single phase AC traction system

- In this type of traction system, AC series motors are used to produce the propulsion of vehicle. This system uses AC voltages from 15-25KV at a frequency of 16.7 (i.e., 16

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2/3) or 25 Hz. This low frequency leads to give better performance and more efficient operation by the series motor.

- This single phase supply is fed to the locomotive unit via a single overhead line while track provides the return path.
- The high voltages (15-25KV) obtained from overhead conductor are stepped down to a suitable motor operating range (typically 300-400V range) using step-down transformer carried by the locomotive unit itself.

Advantages of Single phase AC traction system

- The low frequency operation of overhead line reduces the communication interferences.
- Also, the reactance of the line is low at lower frequency and hence the voltage drop in the line is reduced.
- Because of this low line voltage drop, it is feasible to locate the substations at 50 to 80kms apart from each other.
- Therefore, this system is preferred for main line services where cost of overhead system is not a much important factor and for suburban services where rapid acceleration and retardation are not required.

Composite system

- The above discussed methods have their own merits and demerits. Single phase AC system has less distribution cost whereas DC system has excellent driving capability by DC series motors and three phase system has automatic regenerative braking capacity.
- So by combining the advantages of AC/DC and single/three phase systems, the overall performance of the traction system gives better result than individual system and hence the evolution of composite system.
- Basically composite systems are of two types, namely

Single phase to three phase system
Single phase to DC system

- This traction system is also called Kando system. It consists of single phase16KV, 50 Hz supply which is fed from the substation and is being carried through a single overhead conductor.
- The single phase supply is then converted into three phase supply of the same frequency using phase converter equipment in the locomotive itself. The three phase supply is then fed to induction motors to drive the locomotive.
- It is also possible to develop high starting torque of induction motors by reducing the supply frequency at ½ to 9 Hz by means of inverter controlled through silicon controlled rectifiers.
- The main advantage of this system is that the overhead two conductor arrangement of three phase AC system is reduced to a single overhead conductor and hence more economical.

Single phase to DC system

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- This traction system is most popular and widely used system everywhere. It combines the single phase high voltage AC distribution at industrial frequency with DC series motor traction.
- In this, the overhead line carries single phase, 25KV, 50 Hz supply which is then stepped down to a desired range using step-down transformer located in the locomotive unit itself.
- This single phase supply is then converted into DC using rectifier (in the locomotive) and then applied to DC series motor.
- The advantages of this system include higher starting efficiency, less number of substations, simple substation design and lower cost of fixed installations.

Specific Energy consumption & Factors affecting Specific Energy consumption

It is the energy output of the driving wheel expressed in watt-hour (Wh) per tonne-km (t-km) of the train. It can be found by first converting the energy output into Wh and then dividing it by the mass of the train in tonne and route distance in km. Hence, unit of specific energy output generally used in railway work is :Wh/tonne-km ,(Wh/t-km).

Average and Schedule Speed While considering train movement, the following three speeds are of importance

1. Crest Speed. It is the maximum speed (Vm) attained by a train during the run.

2. Average Speed = distance between stops actual time of run In this case, only running time is considered but not the stop time.

3. Schedule Speed = distance between stops actual time of run + stop time

Adhesive Weight: It is given by the total weight carried on the driving wheels.
Its value is **Wa = x W**, where **W** is **dead weight** and **x** is a **fraction varying from 0.6 to 0.8. 43.45.**

Coefficient of Adhesion: Adhesion between two bodies is due to interlocking of the irregularities of their surfaces in contact. The adhesive weight of a train is equal to the total weight to be carried on the driving wheels. It is less than the dead weight by about 20 to 40%