Performance characteristics of Power Source System and Transmission System of Internal Combustion Engine based Conventional Vehicles

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Abstract— **This paper gives the complete details of basic performance characteristics of Power Source System and Transmission System of Internal Combustion Engine based Conventional Vehicles. This paper gives the basic ideal and practical characteristics between Speed and Torque. This paper provides the basic ideal practical characteristics between speed and power. This paper provides the characteristics between Vehicle Power and Tractive effort on wheels.**

Keywords— Power Source System, Power Train, Transmission System, Differential System, Drivetrain

I. INTRODUCTION

Conventional Vehicle consists of Internal Combustion Engines (IC Engines) that use the conventional energy resources as a fuel which may be Petrol (gasoline) or Diesel or CNG (Compressed Natural Gas) or LPG (Liquified Petroleum Gas). They work on a single energy resource for propulsion. They are of century-old technology. They release burnt gases from the vehicle engine into the atmosphere through a tailpipe [1-4]

Vehicle power sources are characterized by their efficiency, energy storage capabilities, and the type of energy conversion they use, such as the chemical reaction in internal combustion engines and fuel cells versus the electromagnetic fields in electric motors. Traditional vehicles use internal combustion engines, while modern ones increasingly incorporate batteries, fuel cells, and regenerative braking to improve efficiency and reduce emissions. [5-7]

Vehicle transmission characteristics refer to the performance and mechanical properties of the transmission system, which transfers power from the engine to the wheels to control speed and torque. Key characteristics include gear ratios, shift time, efficiency, durability, and drivability, which influence how well the vehicle performs under different conditions and affects factors like fuel economy and comfort. [8-10]

II. PERFORMANCE CHARACTERISTICS OF POWER SOURCE SYSTEM

Vehicle's Power Source Characterization (or) Characteristics means the performance characteristics of Power Source based on the factors such as torque, speed, power output and efficiency etc. Vehicle's Power Source Characteristics is crucial for selecting and designing the best power source for a specific application. The Power Source in Conventional Vehicles is IC Engine and the Power Source in Electric Vehicles is Electric Motor. The Power Source is also called as Power Plant. The Powertrain consists of Power Source, Drivetrain and Wheels.

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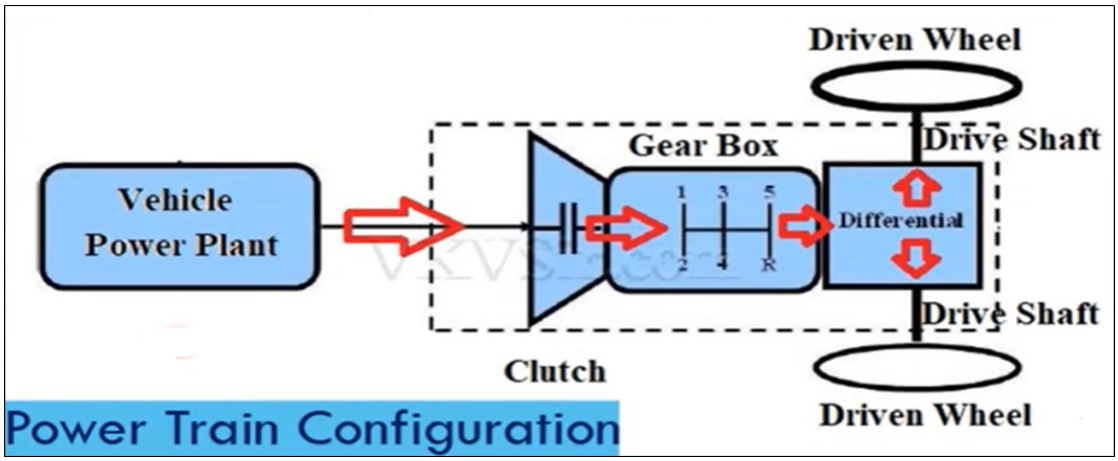

Fig 1: Power Train Configuration

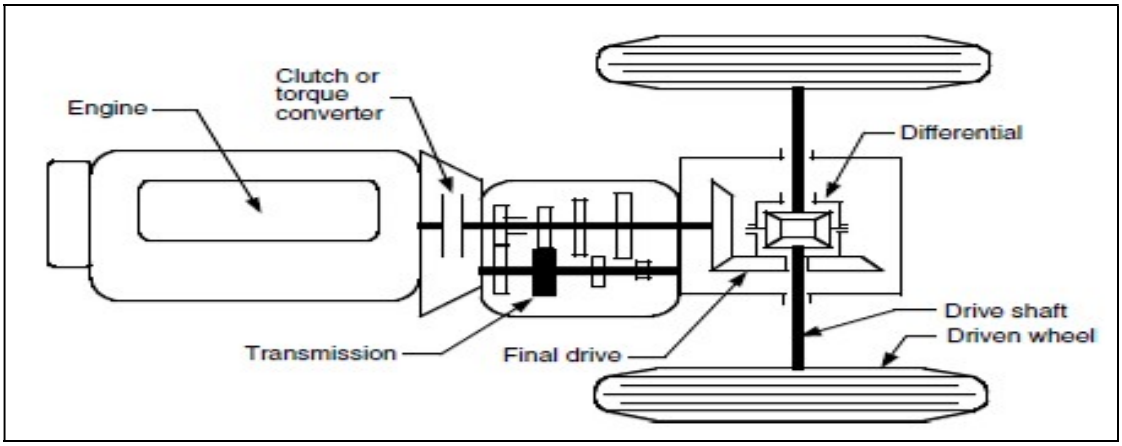

Fig 2: Detailed Power Train Configuration

A. IDEAL (THEORETICAL) PERFORMANCE CHARACTERISTICS OF VEHICLE'S POWER PLANT

The Ideal performance characteristics between Speed and Torque also between speed and power are given in Fig3. This is the theoretical and standard performance characteristics of any vehicle.

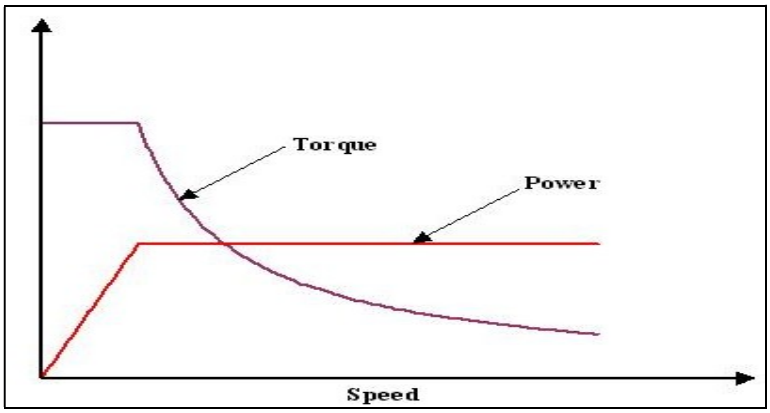

Fig 3: Ideal Performance Characteristics of Vehicle's Power Plant

The Power increases gradually as the speed increases and becomes constant for full speed range. The Torque will be more at starting of the vehicle. This high starting torque is essential for any vehicle. The torque will be constant at lower speeds. The torque decreases gradually as the speed increases.

B. Typical (Practical) performance characteristics of Conventional Vehicle's Power Plant (IC Engine)

The typical performance characteristics between Speed and Torque also between speed and power are given in Fig4. This is the practical performance characteristics of any conventional vehicle.

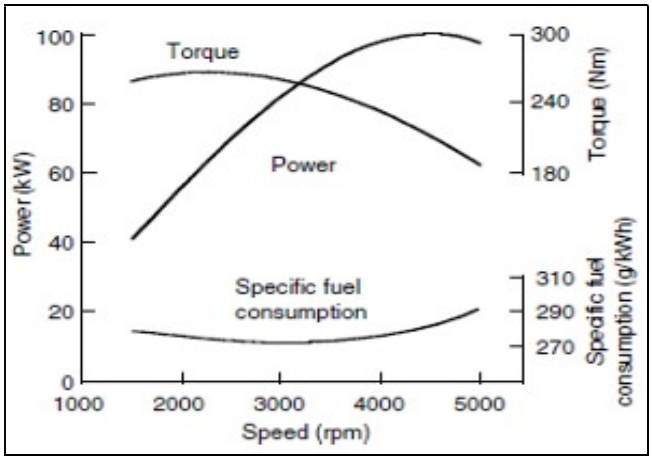

Fig 4: Typical Performance Characteristics of Vehicle's Power Plant

The starting torque will be high and it increases gradually as speed increases. The torque becomes maximum at middle of speed range (2500 rpm in general). After that, the torque decreases gradually as the speed increases. The Power increases gradually as the speed increases. It becomes maximum at a certain high speed. Beyond this point, as the engine torque decreases more rapidly with increasing speed, there will be a decline of engine power output. In Vehicles, the maximum permissible speed of the engine is usually set just a little above the speed of the maximum power output.

III. Performance characteristics of transmission system

Vehicle's Transmission Characteristics explains the management of Powertrain. The Powertrain consists of Power Source, Drivetrain (also called as transmission) and Wheels. The Power Source in Conventional Vehicles is IC Engine and the Power Source in Electric Vehicles is Electric Motor. The Power Source is also called as Power Plant. The Drivetrain consists of Clutch, Gear Box (also called as Transmission), Shaft, differential, axle (also called as driveshaft).

In Power Train, the mechanical power will be transferred from Power Source (or) Power Plant to the wheels through the drivetrain. The Gear Box provides multiple gear ratios to match the engine's speed to the vehicle's speed, which improves fuel economy and performance. Higher gears provide torque for high speeds. Lower gears provide torque for acceleration. Tractive effort (or) Tractive force is a force that the wheels apply to the ground while moving. It is a function of engine torque, gear ratios and wheel radius, and it must be greater than the vehicle's resistance forces (Aerodynamic Drag Force, Rolling Resistance Force, Grade Resistance Force).

The formula to calculate Tractive Force (F_T) is

$$F_T = \frac{T_m \, I_g \, I_0 \, \eta_t}{r_d}$$

Where

T_m = Torque of IC Engine or Electric Motor

I_g = Gear Ratio of Gear Box

I_0 = Gear Ratio of Final Drive

η_t = Drivetrain Efficiency

r_d = Radius of wheels

The transmission characteristics of conventional vehicle with multi gears is shown in Fig 5. It gives the characteristics graph between vehicle speed and tractive effort on wheel. The Conventional Vehicle (with multi gears) characteristics is compared with Electric Vehicle (with single gear) characteristics in Fig 6.

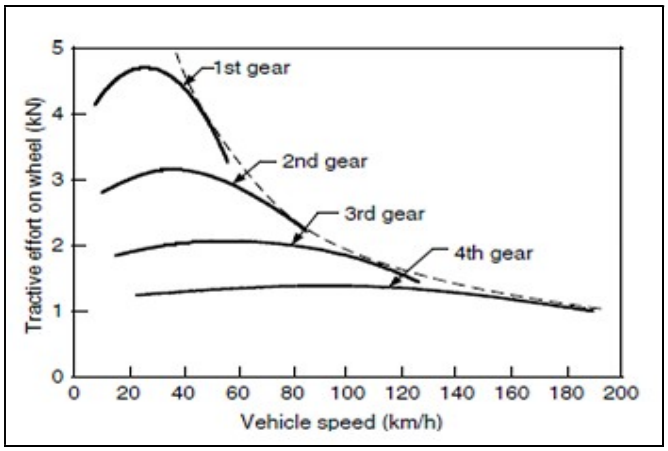

Fig 5: Transmission characteristics of conventional vehicle

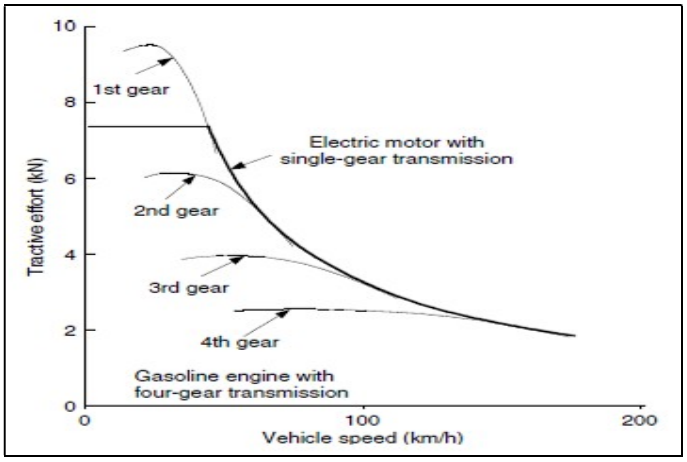

Fig 6: Comparison of Conventional Vehicle and Electric Vehicle

Electric Vehicle with single gear gives similar performance of Conventional Vehicle with multi gears. Hence, Conventional Vehicles can be replaced with Electric Vehicles.

IV. CONCLUSIONS

This paper gives the concept behind the basics of Internal Combustion Engine based Conventional Vehicles. The complete details of basic performance characteristics of Power Source System of Internal Combustion Engine based Conventional Vehicles are provided in this paper. The complete details of basic performance characteristics of Transmission System of Internal Combustion Engine based Conventional Vehicles are discussed in this paper. The basic ideal and practical characteristics between Speed and Torque are provided in this paper. The basic ideal and practical characteristics between speed and power are discussed in this paper. The characteristics between Vehicle Power and Tractive effort on wheels are discussed in this paper. It is concluded that the Electric Vehicle with single gear gives similar performance of Conventional Vehicle with multi gears. Hence, Conventional Vehicles can be replaced with Electric Vehicles.

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