1.4 TRANSMISSION CHARACTERISTICS:

The transmission requirements of a vehicle depend on the characteristics of the power plant and the performance requirements of the vehicle. As mentioned previously, a well-controlled electric machine such as the power plant of an electric vehicle will not need a multi gear transmission. However, an internal combustion engine must have a multi gear or continuously varying transmission to multiply its torque at low speed. The term transmission here includes all those systems employed for transmitting engine power to the drive wheels.

For automobile applications, there are usually two basic types of transmissions: manual gear transmission and hydrodynamic transmission.

1.3.1 Manual Gear Transmission

Manual gear transmission consists of a clutch, gearbox, final drive, and driveshaft. The final drive has a constant gear reduction ratio or a differential gear ratio. The common practice of requiring direct drive (non- reducing) in the gearbox to be in the highest gear determines this ratio. The gearbox provides a number of gear reduction ratios ranging from three to five for passenger cars and more for heavy commercial vehicles that are powered with gasoline or diesel engines. The maximum speed requirement of the vehicle determines the gear ratio of the highest gear (i.e., the smallest ratio). On the other hand, the gear ratio of the lowest gear (i.e., the maximum ratio) is determined by the requirement of the maximum tractive effort or the grade ability. Ratios between them should be spaced in such a way that they will provide the tractive effort–speed characteristics as close to the ideal as possible, as shown in Figure1.1. In the first iteration, gear ratios between the highest and the lowest gear may be selected in such a way that the engine can operate in the same speed range for all the gears. This approach would benefit the fuel economy and performance of the vehicle. For instance, in normal driving, the proper gear can be

selected according to vehicle speed to operate the engine in its optimum speed range for fuel-saving purposes. In fast acceleration, the engine can be operated in its speed range with high power output. This approach is depicted in Figure 1.5.3.2.For a four-speed gear box, the following relationship can be established.

$$\frac{i_{g1}}{i_{g2}} = \frac{i_{g2}}{i_{g3}} = \frac{i_{g3}}{i_{g4}} = K_g \qquad \text{…….eq1}$$

and

$$K_g = \sqrt[3]{\frac{i_{g1}}{i_{gg4}}}, \qquad \text{……..eq2}$$

where *ig*1, *ig*2, *ig*3, and *ig*4 are the gear ratios for the first, second, third, and fourth gear, respectively. In a more general case, if the ratio of the highest

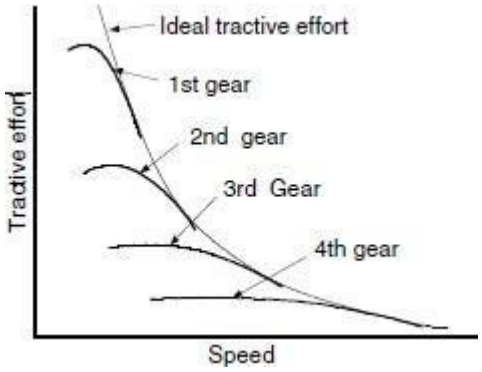

Figure1.1: Tractive effort characteristics of a gasoline engine-powered vehicle

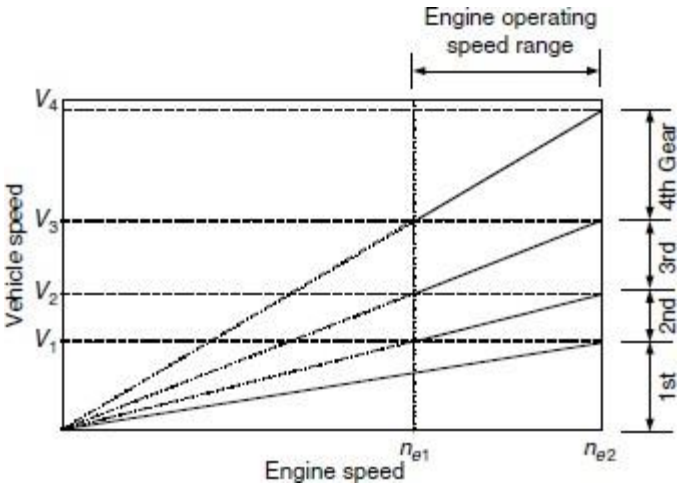

Figure1.2: Demonstration of vehicle speed range and engine speed range for each gear

gear, *ign*(smaller gear ratio), and the ratio of the lowest gear, *ig*1 (largest gear ratio), have been determined and the number of the gear *ng* is known, the factor *Kg* can be determined as

$$K_g = \left(\frac{i_{g1}}{i_{gn}}\right)^{(n_t-1)}, \qquad \text{.....eq3}$$

and each gear ratio can be obtained by

$$\begin{aligned} i_{gn-1} &= K_g i_{gn} \\ i_{gn-2} &= K_g^2 i_{gn} \\ &\vdots \\ i_{g2} &= K_g^{n_t-1} i_{gn}. \end{aligned} \qquad \text{.....eq4}$$

For passenger cars, to suit changing traffic conditions, the step between the ratios of the upper two gears is often a little closer than that based on (eq4).That is,

$$\frac{i_{g1}}{i_{g2}} > \frac{i_{g2}}{i_{g3}} > \frac{i_{g3}}{i_{g4}}. \qquad \text{.....eq5}$$

This, in turn, affects the selection of the ratios of the lower gears. For commercial vehicles, however, the gear ratios in the gearbox are often arranged based on (eq5).

Figure 1.3 shows the tractive effort of a gasoline engine vehicle with four gear transmission and that of an electric vehicle with single-gear transmission. It is clear that electric machines with favorable torque–speed characteristics can satisfy tractive effort with simple single-gear transmission.

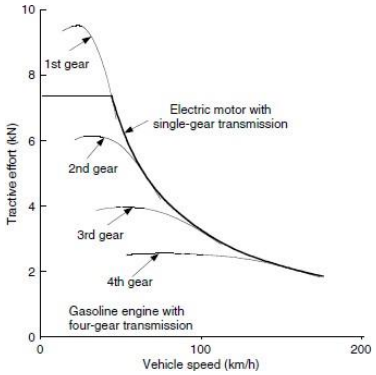

Figure1.3: Tractive efforts of a gasoline engine vehicle with four-gear transmission and an electric vehicle with single-gear transmission.