3.1 INTRODUCTION TO ELECTRIC COMPONENTS USED IN HYBRID AND ELECTRIC VEHICLES

The term hybrid vehicle refers to a vehicle with at least two sources of power. Hybrid-electric vehicle indicates that one source of power is provided by an electric motor. The other source of motive power can come from a number of different technologies, but is typically provided by an internal combustion engine designed to run on either gasoline or diesel fuel. As proposed by Technical Committee (Electric Road Vehicles) of the International Electro technical Commission, an HEV is a vehicle in which propulsion energy is available from two or more types of energy sources and at least one of them can deliver electrical energy. Based on this general definition, there are many types of HEVs, such as:

- the gasoline ICE and battery
- diesel ICE and battery
- battery and FC
- battery and capacitor
- battery and flywheel
- Battery and battery hybrids.

Most commonly, the propulsion force in HEV is provided by a combination of electric motor and an ICE. The electric motor is used to improve the energy efficiency (improves fuel consumption) and vehicular emissions while the ICE provides extended range capability.

Energy Savings Potential of Hybrid Drive trains

In terms of overall energy efficiency, the conceptual advantages of a hybrid over a conventional vehicle are:

1. **Regenerative braking.**

A hybrid can capture some of the energy normally lost as heat to the mechanical brakes by using its electric drive motor(s) in generator mode to brake the vehicle.

2. More efficient operation of the ICE, including reduction of idle:

A hybrid can avoid some of the energy losses associated with engine operation at speed and load combinations where the engine is inefficient by using the energy storage device to either absorb part of the ICE's output or augment it or even substitute for it. This allows the ICE to operate only at speeds and loads where it is most efficient. When an HEV is stopped, rather than running the engine at idle, where it is extremely inefficient, the control system may either shut off the engine, with the storage device providing auxiliary power (for heating or cooling the vehicle interior, powering headlights, etc.), or run the engine at a higher-than-idle (more efficient) power setting and use the excess power (over auxiliary loads) to recharge the storage device. When the vehicle control system can shut the engine off at idle, the drivetrain can be designed so that the drive motor also serves as the starter motor, allowing extremely rapid restart due to the motor's high starting torque.

3. Smaller ICE:

Since the storage device can take up a part of the load, the HEV's ICE can be down sized. The ICE may be sized for the continuous load and not for the very high short-term acceleration load. This enables the ICE to operate at a higher fraction of its rated power, generally at higher fuel efficiency, during most of the driving. There are counterbalancing factors reducing hybrids' energy advantage.

4. Electrical losses

Although individual electric drivetrain components tend to be quite efficient for one-way energy flows, in many hybrid configurations, electricity flows back and forth through components in a way that leads to cascading losses. Further, some of the components may be forced to operate under conditions where they have reduced efficiency. For example, like ICEs, most electric motors have lower efficiency at the low-speed, low-load conditions often encountered in city driving. Without careful component selection and a control strategy that minimizes electric losses, much of the theoretical efficiency advantage often associated with an electric drivetrain can be lost.

HEV Configurations

In Figure 2 the generic concept of a hybrid drivetrain and possible energy flow route is shown. The various possible ways of combining the power flow to meet the driving requirements are:

i. power train 1 alone delivers power

ii. Power train 2 alone delivers power

iii. Both power train 1 and 2 deliver power to load at the same time

iv. Power train 2 obtains power from load (regenerative braking)

v. power train 2 obtains power from power train1

vi. Power train 2 obtains power from power train 1 and load at the same time

vii. Power train 1 delivers power simultaneously to load and to power train2

viii. Power train 1 delivers power to power train 2 and power train 2 delivers power a ton load.

ix. power train 1 delivers power to load and load delivers power to power train 2.

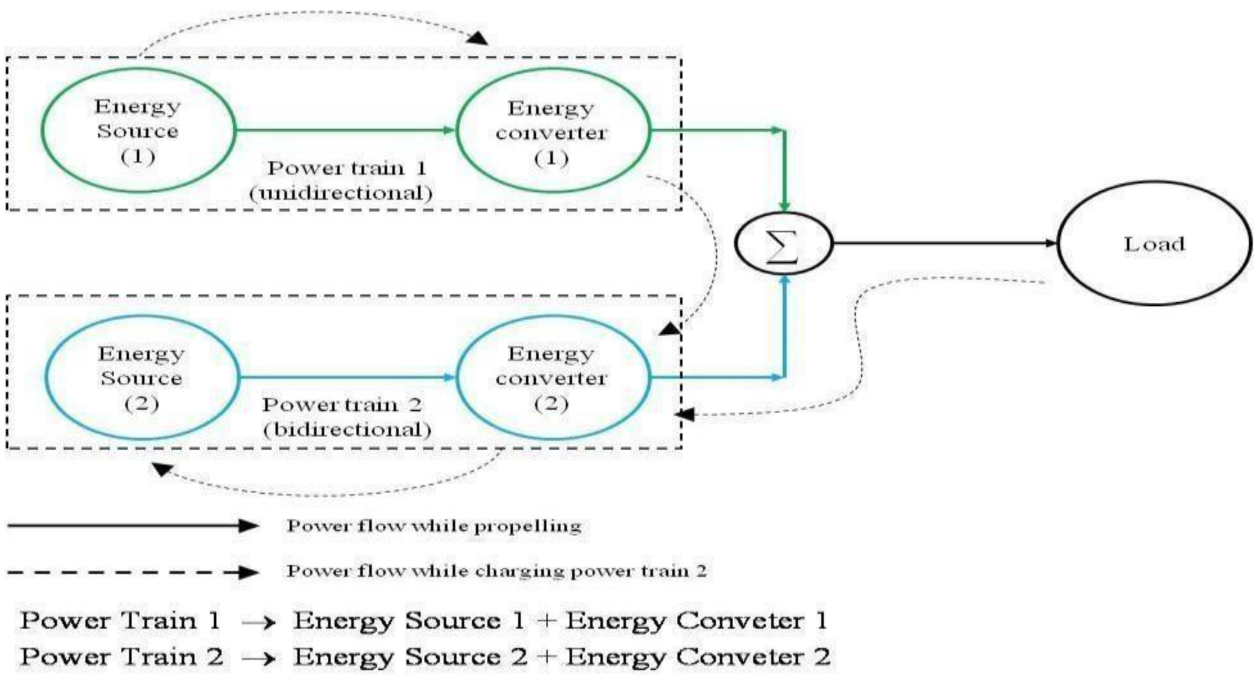

Figure 2: Generic Hybrid Drivetrain

The load power of a vehicle varies randomly in actual operation due to frequent acceleration, deceleration and climbing up and down the grades. The power requirement for a typical driving scenario is shown in Fig. The load power can be decomposed into two parts:

i. steady power, i.e. the power with a constant value
ii. Dynamic power, i.e. the power whose average value is zero

In HEV one powertrain favors steady state operation, such as an ICE or fuel cell. The other powertrain in the HEV is used to supply the dynamic power. The total energy output from the dynamic powertrain will be zero in the whole driving cycle. Generally, electric motors are used to meet the dynamic power demand. This hybrid drivetrain concept can be implemented by different configurations as follows:

- Series configuration
- Parallel configuration
- Series-parallel configuration
- Complex configuration