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Recent Trends in Transportation Technology as Hybrid-Electric Vehicle: A Review

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Abstract : *Hybrid electric vehicles are future for automobile industry. Among all other technologies modern HEVs are most promising technology. Deterioration of air quality and decrease in petroleum resources are becoming major threats to human beings. In order to reduce consumption of non-renewable resources, combination of multiple energy resources is imperative in 21st century. HEVs are driven by intelligent combination of ICE propulsion system and electric propulsion system. Modern HEVs are highly efficient due to use of efficiency improving technologies such as regenerative breaking and reduce idle emission by shutting down ICE when not needed. The descriptive aspect of this paper is to review the HEVs their advantages, classification, power management strategies as well. The methodology used in this paper is descriptive library and analytical.*

Keywords *- Modern HEVs, efficiency improving technology, reduce idle emission, regenerative breaking, power management strategies.*

I. INTRODUCTION

Conventional vehicles with ICE provides good performance and long operating range by utilization high energy density advantages of petroleum fuels however conventional ICE bear disadvantages of poor fuel economy and environmental pollution. Main reasons of poor fuel economy are engine fuel efficiency characteristics are mismatched with real operating conditions requirements and dissipation of vehicle K.E. during braking. Battery powered electric vehicle possess some advantages over ICE vehicle such as high energy efficiency, zero pollution but performance specially operating range per battery charge is far less than ICE.

In order to overcome these problems, there is perfect solution of HEVs which smartly uses two power sources providing benefits of both ICE and EV. HEVs are able to give limitless performance with higher efficiency, less noise, less pollution without changing driving experience. All types of transportation vehicles can be hybridized for making environmental friendly. Many cities are switching their public transportation and service vehicles over to hybrid cars and buses as a part of the program to become more environmentally responsible [1].

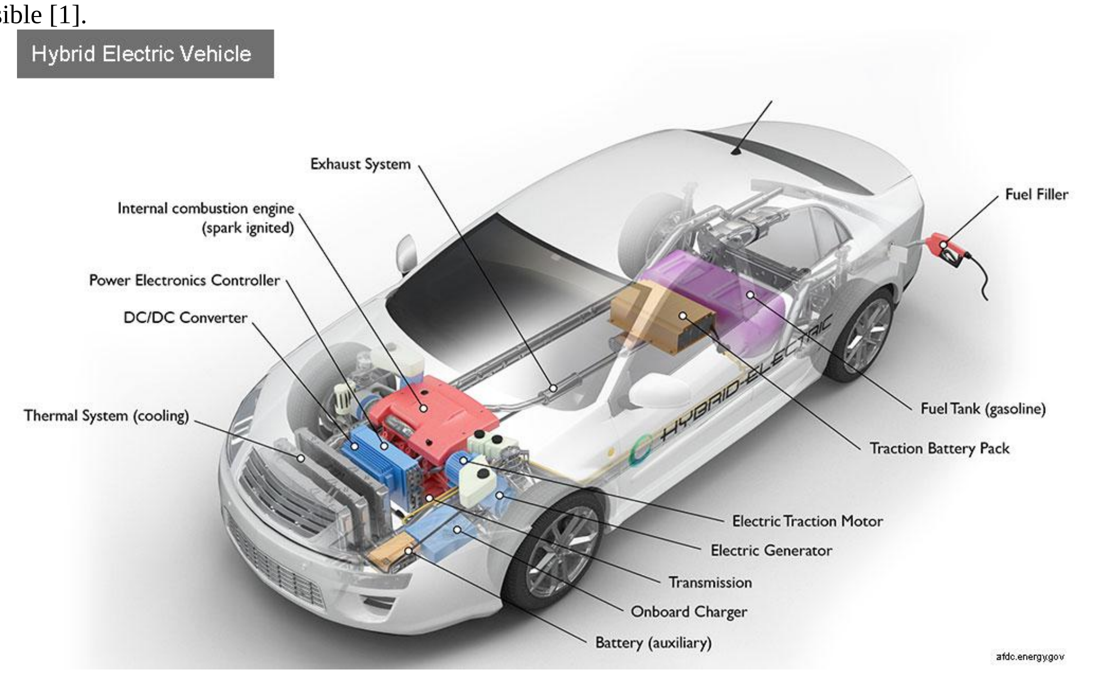


Fig 1. Basic components of HEVs [2]

II. HYBRID-ELECTRIC VEHICLE MAJOR TECHNIQUE UNITS

In order to combine two power sources each unit of HEVs is specially designed to meet new efficient power producing source requirements.

Engine-Most of the current hybrid vehicles, like the Ford Escape and the Toyota Prius use Atkinson cycle engines instead of the conventional Otto-cycle. The Atkinson-cycle engine is up to 10% more efficient than a conventional petrol "Otto" engine. An ICE in a hybrid vehicle is required to produce electricity depending on the drive train technology deployed. The exceptions are the serial hybrids. They need to have some of the traditional characteristics intact as the engine is required to supplement the electric traction motors in driving the vehicle and in some applications drive the vehicle fully without electric assistance.This means the engine is not the only source of power and therefore can be smaller and driven, when it is powered on in its mostefficient operations range where it gives the most power. [3]

Motor / Generator –Addition of motor is what makes any vehicle hybrid. Special designs have to be taken under considerations. Special motors have to be designed in order move vehicle from rest position. High starting torque is required for this purpose. Weight is also one of consideration to selection of motors in HEVs.Most machines used in Hybrid vehicles are BLDC motors.Also, PMM are used in series HEVs like Toyota Prius but it requires cooling that add weight. 3-Phase induction motors can air cooled but it requires more complex transmission.
Torque requirement characteristic in different operations is as follows-

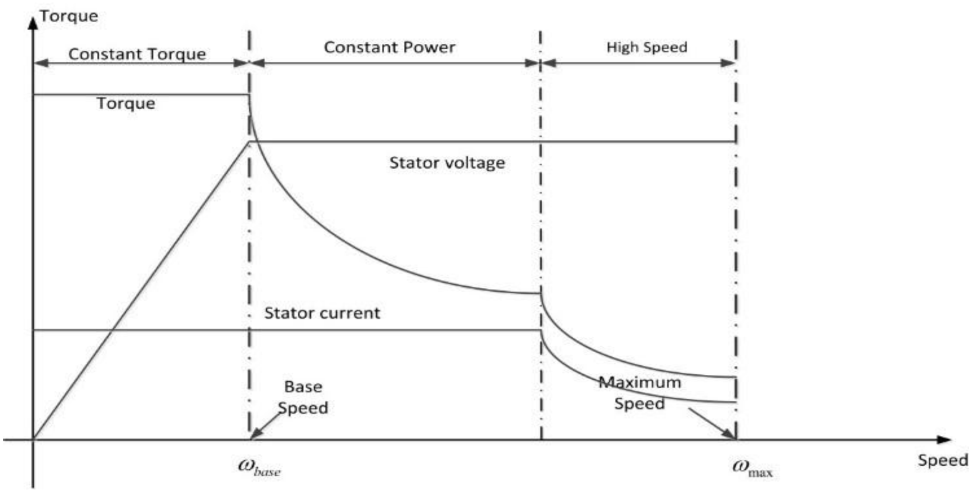


Fig.2. Torque-Speed characteristics curve

The required tractive Torque of motor should be equal to tractive Torque at wheel.

$T_w = F_t * R_w$ -----------(1)

Where, $F_t = F_r$+Fg+Fd+Fie

F_r= Rolling resistance

F_d=Aerodynamic drag

F_{ie}=Inertial force - during acceleration including linear and rotational inertias due to vehicle mass and rotating component of gear train and wheel. [4]

PCU and electronics-The brain of hybrid vehicle expertly controlling electricity. PCU is generic term for any embedded system that controls one or more electrical system. The power control unit converts AC/DC, DC/DC power and appropriately adjusts electrical voltage. [5]
Inverter:-Convert electricity and supply it from battery to motor.
Boost converter:-It controls voltage and boost low voltage. It steplessly increase normal roughly 200V DC supply voltage to maximum of 650V DC as required. [6]

Resource Battery- The main development focus of HEVs batteries is on high energy densities, safety, lifetime, and cost on cell level, different cell formats and cell chemistries are discussed and general battery pack is highlighted. For battery packs, the major focus is on lightweight construction and cost efficient electric and electronic architectures. Li-ion batteries have high energy density amount to hold energy by weight, volume than other type like previous gen. NIMH batteries which is used in all Prius models. Battery pack of second gen

Toyota Prius consist of 28 Panasonic prismatic nickel metal hybrid modules each consisting of six 12 V cells series connected to produce 206.1 V weight is 53.3 KG. Discharge power capacity 20KW at 50% of SOC.

Where LEXUS sport batteries uses 240 cells to produce 288V. [7] Booster changes this to 500V this battery pack provides 40% more power than Toyota Prius despite being 18% smaller.

Power Split Device- It is heart of HEVs. It is cleaver gearbox that hooks ICE, generator and electric motor together. It allows vehicle to operate like in parallel, series, parallel-series mode. Finally it allows generator to start engine hence car does not need starter.

It is planetary gear set shown in fig:

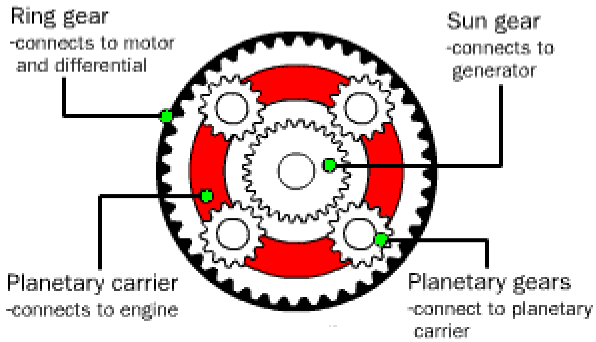


Fig. 2: Planetory gear set [8]

Electric motor is connected to ring gear of set which directly connected with differential to drive wheels so it determines speed of car. Generator is connected to sun gear and engine is connected to planet carrier.

III. HEVs Architecture

HEVs are classified according to drive train. A drivetrain is the collection of components that deliver power from a vehicle's engine or motor to the vehicle's wheels. In hybrid-electric cars, the drivetrain's design determines how the electric motor works in conjunction with the conventional engine. The drivetrain affects the vehicle's mechanical efficiency, fuel consumption, and purchasing price.

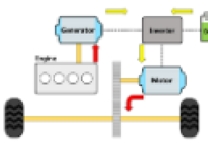
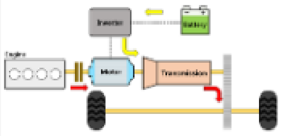
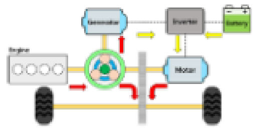
1 –Series HEVs – In series HEVs only electric motor drives drivetrain and smaller ICE called range extender is used.The engine is typically smaller in a series drivetrain because it only has to meet certain power demands; the battery pack is generally more powerful than the one in parallel hybrids in order to provide the remaining power needs.

2- Parallel HEVs – In parallel HEVs both EM and ICE drives drivetrain. Till 2013 parallel HEVs use full sized ICEs with small (20KW) electric motor and small battery pack to supplement ICE but after 2015 parallel HEVs with over 50KW are available enabling EV mode which is more efficient than non-hybrid vehicles.

3- Power Split HEVs – This are pure hybrid vehicles which smartly connects or disconnects ICE and EM according to driving conditions. This system incurs higher costs than a pure parallel hybrid since it requires a generator a larger battery pack, and more computing power to control the dual system. Yet its efficiencies mean that the series/parallel drivetrain can perform better—and use less fuel—than either the series or parallel systems alone [9].

4- PHEVs-The plug-in hybrid is usually a general fuel-electric (parallel or serial) hybrid with increased energy storage capacity, usually through a lithium-ion battery, which allows the vehicle to drive on all-electric mode a distance that depends on the battery size and its mechanical layout (series or parallel) [10].

Table 1:Advantages and disadvantages of hybrid electric vehicle system [11]

	Series Hybrid	Parallel Hybrid	Power-split Hybrid
Layout			
Advantages	· Engine operates most efficient region · Simple drive train	· Minimal design changes from conventional vehicle · Less energy conversion	· Combines the advantages of series and parallel hybrid
Disadvantages	· Requires a large motor · Energy conversion losses	· Engine cannot operate at its best efficiency · Low efficiency of automatic transmission	· Design and control are complex than the other two HEV types

Fuel Efficiency-All hybrid vehicles does not have a goal of fuel efficiency; the LA Ferrari sports car, for example, uses the engine &motor combination for high performance. Most hybrids, however, do exploit on the electric motor's energy efficiency to improve fuel economy—when the vehicle is running on the motor's power, it consumes no fuel. Most hybrid cars have better fuel economy than their gas-only counterparts; for example, the Honda Civic hybrid model rated 7 liters per 100 kms versus the standard Civic's 8.11 litres per 100 kms, The Hyundai Sonata hybrid managed 8.5 liters per 100 kms compared to the Sonata SE's 10.5 liters per 100 kms, and the Ford Fusion hybrid achieved 6.918 liters per 100 kms against the SEL's 9.8 liters per 100 kms. Because of absence of regenerative braking technology non hybrid cars consume more fuel if they are subjected to breaking and acceleration frequently, which is common in city driving conditions.

Purchase Price-Due to their greater complexity and the relatively high cost of rechargeable batteries, hybrid cars command a premium of at least a few thousand dollars over their conventional counterparts in terms of initial purchase price. However, according to consumer reports, most hybrids make up the price difference in about a year's worth of driving due to money saved through fuel efficiency. These are just a few of the major points to be considered for understanding hybrid cars versus their gas counterparts. The bottom line is that hybrid cars are more fuel efficient and environmentally friendly than gas cars, but they are also more expensive. As a result, it is up to individuals to become informed consumers in order to choose a car that is right for them.

Tailpipe Emissions- A typical Hybrid car produce 90% fewer emissions compared to traditional vehicles, while operating on electric motor vehicle has no emission. In addition, hybrid tend to rely mostly on motor in slow speed, it reduces emissions in high congestion, stop and go condition.

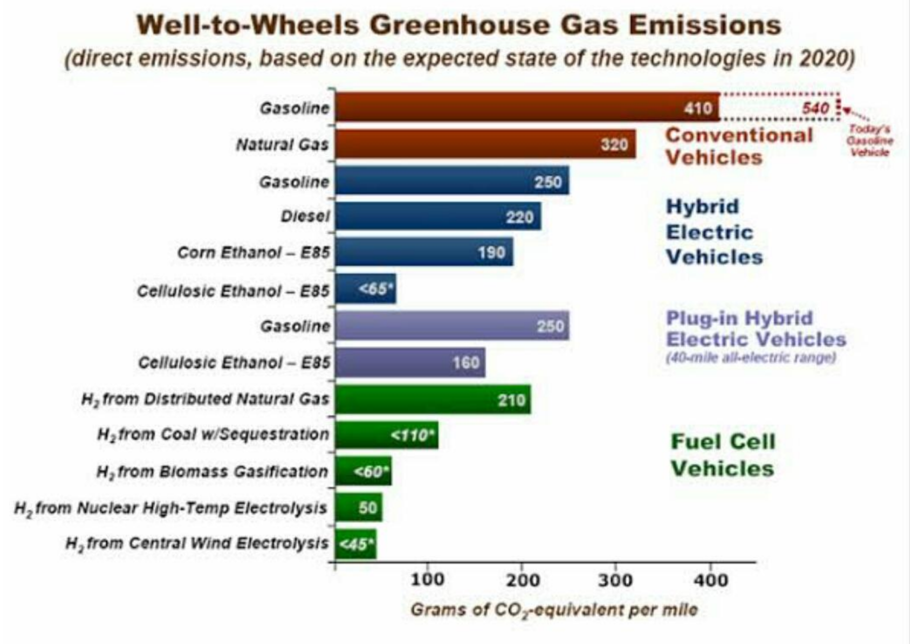


Fig. 3: Well-to-Wheels Greenhouse Gas Emission [12]

IV. CONCLUSION

The paper represents a comparative analysis on benefits provided by hybrid vehicle against diesel powered vehicles. A hybrid is a fuel efficient vehicle having electric motor and ICE. It is evident from the analysis made in the paper that hybrid vehicles offer more benefits in maintenance, are cost-effective, and most importantly environmental-friendly and future ready.

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