A REVIEW OF HYBRID ELECTRIC VEHICLE: A TREND AND ADVANCED TECHNOLOGIES

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Abstract- *HEVs are likely to reduce greenhouse emissions. This may lead to cleaner operations. Nowadays, fossil fuels are also decreasing. Today, automobile transportation is in a crisis concerning the high price of fuels. In the future, the crisis will take on unprecedented proportions. The demand for fuel is increasing that's why leading to problems like Air pollution, Global warming, the Reduction of fossil fuels, etc. which has many adverse effects on the environment. This study focused on the technical aspects of various types of HEVs and Advance technologies of Hybrid electric vehicles. Also, here discussed its environmental impacts.*

Keywords: hybrid electric vehicle (HEV), power trains, Global warming, Regenerative braking.

1. Introduction:

The essence of HEVs is almost as old as the automobile technology. To move the vehicle a hybrid electric vehicle uses two or more distinct power sources, normally a combination of two energy sources like electricity and conventional fuel-powered vehicles. As of April 2020 over 17 million HEVs have been sold worldwide since their inception in 1997. HEVs research had been done by automobile companies in consideration of climate change which also leads to global warming due to day to day increasing use of fuel. Its main benefit for the environment is the improvement in Air Quality and improves efficiency. It has great potential for not only a better fuel economy but also fewer emissions. In recent years it has manifested itself to be effective even though a momentary solution to displace. Air dependency has been mitigated by the utilization of fossil fuels. It also solved almost all the problems that ICE faced. Conventional vehicles like the internal combustion engine give better performance characteristics and have a wide operating range. The internal combustion engine in hybrid-electric is much smaller and lighter also more efficient than the engine in a conventional vehicle. HEV makes use of efficiency-improving technologies such as regenerative braking, which converts the vehicle's kinetic energy to charge the battery, rather than wasting it as heat energy as conventional brakes do. In this paper it is exhibited that the new technologies in HEVs. [4, 11]

2. Classification of HEVs:

The hybrid power system according to the structure divided into three main types, like series, parallel, and combined hybrid.

A. Series HEV:

Series Hybrid Electric Vehicle is the main characteristic of the driving force of the vehicle only from the motor. It has three power train engine, generator, and electric motor they are connected in series connection. PHEVs run alone on electricity until the battery needs to get recharged. For shorter distances, this vehicle doesn't use fuel. It is more costly than PHEVs.

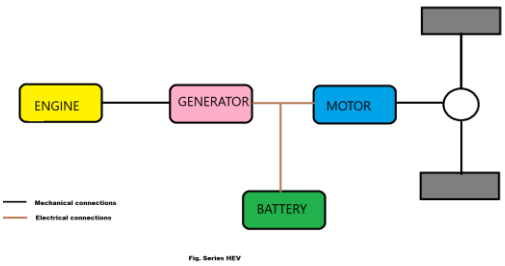
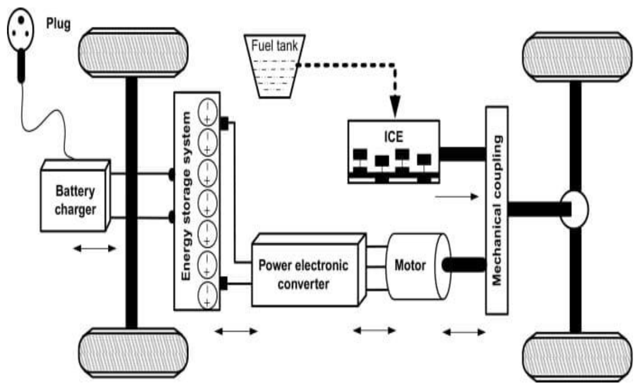


Fig-1: Series HEVs. [7]

B. Parallel HEV:

The important characteristics of a parallel hybrid electric vehicle (PHEV) is that the motor and the engine can provide the driving force of the vehicle simultaneously or separately. They are connected mechanically. Then the electrical system can be designed with a reduced capability, i.e. cost and volume capacity.



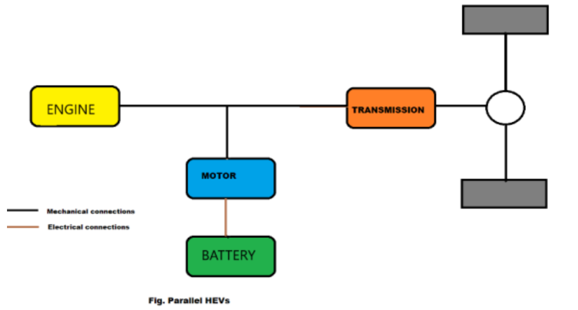


Fig-2: Parallel HEVs. [7]

C. Combined HEV:

Here, series and parallel system both are merged to get more advantages and benefits.

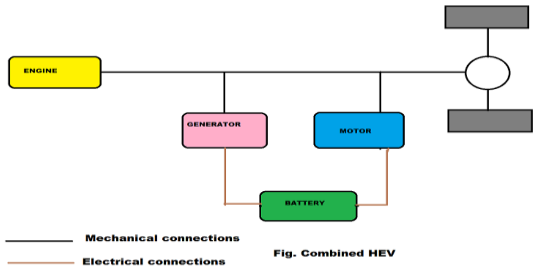


Fig-3: Combined HEVs. [7]

3. Plug-In Hybrid Electric Vehicle (PHEVs) :

These types of vehicles are much closer to HEVs. It has a larger battery pack.it can be charged by the engine as well as electricity supply. By external charging stations also it can be charged. When the battery emptied, the conventional engine turns on and the vehicle operates as a conventional, non-plug-in hybrid. PHEVs operates on all electrical mode it not produce many pollutants.

Example: Toyota Prius [14]

Fig-4: Schematic diagram of PHEVs. [6]

i. Series PHEVs:

It also called extended-range hybrid electric vehicles. Only the electric motor turns the wheels; the engine is only used to induce electricity. These can run simply on electricity until the battery needs to be recharged.

ii. **Parallel PHEVs:**

It also called blended PHEVs. Both the engine and motor are mechanically coupled to the wheels, and both propel the vehicle under most driving conditions. The Electric operation usually occurs only at a low range.

4. Comparison of Hybrid levels of EVs.

Hybrid Type	**Micro Hybrid**	**Mild Hybrid**	**Full Hybrid**
IC Engine	Conventional	Downsized	Downsized
Motor Power	3-5 KW	7-15 KW	>30 KW
Motor Voltage	12 V	60-200 V	200-600 V
Hybridization	<10%	10-30%	>40%
Energy Saving	5-10%	20-30%	30-50%
Functions	Start/stop Reg. Braking Accessories powering	Start/stop Reg. Braking Electric Assist	Start/stop Reg. Braking Electric Traction
Cost	Low	Medium	High
Examples	Mercedes Smart	Honda Insight	Toyota Prius

Table. 1 Hybrid level of EVs. [4]

5. HEVs Advanced Technologies:

HEVs put the promise of reducing CO_2 emissions from the transport sector significantly. The key technologies include the following aspects:

i. **Advanced internal combustion engine technology:**

Like conventional ICE HEVs also require advanced technology to achieve maximum fuel economy and minimum greenhouse gas emissions. Here, as compared to conventional ICE the gasoline engines are smaller also give higher efficiency. Also it has High-Pressure Injection, Lower Compression Ratios, and Higher Peak Cylinder Pressure. [7]

ii. **Battery charging and storage technology:**

An advanced technology vehicle battery stores chemical energy in its active materials and converts it into electrical energy employing an electrochemical reaction. Li-ion batteries are preferred in advanced technology vehicles because of their cold-weather performance, abuse tolerance and ability to recharge at high rates. [9]

iii. **Regenerative braking:**

It is an energy recovery mechanism that slows the vehicle down by converting kinetic energy into another form, which can be used either immediately or stored until needed. It allows dissipating heat. The energy that is recouped during braking is saved and re-routed into the battery packs, which in turn provides power to the electric motor that then supplements the main drive engine. This electricity is stored in a battery until needed by the electric motor.it has the potential to improve fuel economy and performance of vehicles. [11]

iv. **Electric accessories:**

It involves power steering and air conditioning are powered by a motor instead of being attached to the combustion engine. The Battery pack in HEV has much higher voltage as well as reduce current and I2R losses.

v. **Lower the cost:**

It consumes less gasoline as compared to conventional vehicles, so it minimizes the cost of fuel. [7]

vi. **Torque Assist:**

The 'motor' function of the ISG uses the energy stored in the advanced dual battery system to supplement the engine's power during acceleration. In doing so, the Smart Hybrid technology reduces the load on the engine, thereby increasing fuel efficiency and lowering emissions.

vii. **Automatic Start/Shutoff:**

This technology automatically shuts off the engine when the automobile falls to rest position to stop as well as restarts when the accelerator is pressed. It also prevents energy from wasted in idling.

6. Environmental issues:

The development of internal combustion engine automobiles is one of the biggest achievements of modern technology but, it has some adverse effects. It mainly involves air pollution, global warming, the reduction of fossil fuels, etc. it causes a serious problem for living things. [10, 15]

i. **Air pollution:**

Nitrogen oxides (NO_X) forms by the reaction between nitrogen in the air and oxygen. Nitrogen is an inert gas. High temperature and pressure in ICE create favourable conditions for the formation of NO_X. It also reacts with atmospherical water and forms nitric acid (HNO_3). This concept is called 'Acid rain'. Which also hazardous.

Carbon Monoxide forms from incomplete combustion of hydrocarbons due to deficiency of O_2. It is poisonous for humans as well as animals also. It can be reacted with blood cells and leads to death.

Unburned HCs results of the incomplete combustion of HCs. It may be harmful to live organisms. It is also responsible for ozone layer depletion.

ii. **Global warming:**

It is the result of the 'Greenhouse effect' generated by Co_2 and other gases like CH_4. The transportation sector is now a major contributor to Co_2 emissions. Co_2 gas in the atmosphere performs a major role in heating up of the atmosphere, due to trapping of infrared rays.

iii. **Reduction of fossil fuels:**

Fossil fuel energy affects the environment and health due to the emissions and impact of mining practices.

7. Case Study:

Toyota Prius:-

The Prius creates high customer value also provides public benefits without requiring a sacrifice. In 2012, Prius had 51.5% of the US Hybrid market share. The Prius Plug-In Hybrid ranked as the second most sold plug-In electric car in the year 2012. [6] It listed as the world's all- time third best-selling plug-In car in 2014.

- **The First generation: (1997-2004)**
- The Toyota Prius was introduced in 1997 in Japan but it was launched worldwide in 2000.
- The Prius was powered by a Toyota Hybrid System with two engines, a gasoline 1.5 litre, and an electric 288V.
- Top speed- 160 km/h
- Fuel economy- 5.1 L/100Km
- Co_2 emissions- 138 g/km
- **The Second generation: (2004-2006)**
- This version of Toyota Prius is said to be the most advanced edition of this HEV which is now powered by the second generation of the Toyota Hybrid System engine.
- A high-end liquid crystal display.
- Rear-view camera for extra safety and blind-spot assist.
- Top speed- 170 km/hr
- Fuel economy- 4.7 L/100Km
- Co_2 emissions- 104 g/km
- **The Third generation: (2011-2016)**
- new headlight design
- Smaller grille under the hood.
- Larger air-scoop in the front bumper for cooling.
- The 1.8-liter Atkinson-type gasoline engine was built to recharge the batteries whenever are needed.
- Previous 1.5-liter engine to the 1.8-liter, the car had a better fuel-efficiency.
- Top speed- 180 km/h
- Fuel economy- 4 L/100Km
- Co_2 emissions- 92 g/km
- **The Fourth generation: (2015-Present)**
- In 2016, it reached its fourth generation.
- Impressive fuel-efficient vehicle.
- A double-wishbone suspension in the rear to enhance comfort and stability.
- very good visibility for the driver
- It has a big trunk.
- Top speed -180 km/h
- Fuel economy- 3.3 L/100Km
- Co_2 emissions- 76 g/km.[18]

In this case study, all four generations are explained, the strengths of this HEV are best potential for better fuel economy, good performance, smoother transmission, advanced technologies, minimal impact on environment, etc. Also the concern about environment is growing. It is likely that Price of HEVs will reduce due to increase in production rate of hybrid electric vehicles. [5]

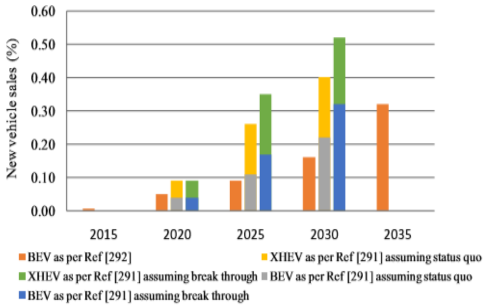


Chart-1: Medium- and long-term sales of hybrid vehicles [3]

8. Conclusion:

The role of HEVs in the transport sector is the need of the hour. HEVs offer many advantages as reducing oil consumption, low effects on climate change, low harmful emissions. But technical and socio-economic challenges to use of HEVs. This includes heavyweight and large size of batteries, and the need for fast charging facilities.

9. References:

1. Travis E. McWhirter, "Tracked vehicle physics-based energy modelling and series hybrid system optimisation for the Bradley fighting vehicle", Int. J. Electric and Hybrid Vehicles, Vol. 12, No. 1, 2020, 14 pages.
2. Martin Weiss, "Fully electric and plug-in hybrid cars - An analysis of learning rates, user costs, and costs for mitigating CO2 and air pollutant emissions.", Journal of Cleaner Production, 212 (2019) 1478e1489, 2019,12 pages.
3. Krishna Veer Singh, "A Comprehensive review on hybrid electric vehicles: Architectures and components", Journal of Modern Transportation27, 77-107, 2019, 31 pages
4. Dr. K.V. Vidyanandan, "Overview of Electric and Hybrid Vehicles", ResearchGate, March 2018, 8 pages.
5. Liang Li, "Structure optimization and generalised dynamics Control of Hybrid Electric Vehicles", Modeling Dynamics and Control of Electrified Vehicles, 2018
6. Shailendra Jain, "Fundamentals of Power Electronics Controlled Electric Propulsion", Power Electronics Handbook (Fourth Edition), 2018
7. Hamiao wang, "Overview of Hybrid Electric Vehicle Trend", Advances in Materials, Machinery, Electronics II, 2018, pages 7.
8. Ojas M. Govardhan, "Fundamentals and Classification of Hybrid Electric Vehicles", International Journal of Engineering and Techniques - Volume 3 Issue 5, Sep - Oct 2017, 5 pages.
9. Ahmed Kiani, "Electric Vehicle Market Penetration Impact on Greenhouse Gas Emissions for Policy-Making: A Case Study of United Arab Emirates" International Scholarly and Scientific Research & Innovation, 2017, 8 pages.
10. Alexander Kapustin, "Methodology to Evaluate the Impact of Hybrid Cars Engine Type on their Economic Efficiency and Environmental Safety", Transportation Research Procedia 20 (2017) 247 – 253, 2016, 7 pages.

11. Rushikesh Trushar Soni," Hybrid Electric Vehicle", IOSR Journal of Mechanical and Civil Engineering, 2015, Volume 12, 4 pages.
12. Karan C. Prajapati, "Hybrid Vehicle: A Study on Technology" International Journal of Engineering Research & Technology (IJERT), Vol. 3 Issue 12, December-2014, 8 pages.
13. Aishwarya Panday, "A Review of Optimal Energy Management Strategies for Hybrid Electric Vehicle",International Journal of Vehicular Technology, Volume 2014, 19 pages
14. Caiying Shen, "A Comprehensive Overview of Hybrid Electric Vehicles", International Journal of Vehicular Technology ,2011,Volume 2011, 7 pages
15. Alyssa Ann Xarras,, "A study on hybrid cars: Environmental effects and consumer habits", Worcester Polytechnic Institute, 2010.
16. Offer G. J. " Comparative analysis of battery electric, hydrogen fuel cell and hybrid vehicles in a future sustainable road transport system", Energy Policy (2009), 12 pages.
17. Jinming Liu, "Modeling and Control of a Power-Split Hybrid Vehicle", IEEE transactions on control systems technology, vol. 16, no. 6, november 2008, 10 pages.
18. https://www.autoevolution.com/toyota/prius/

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