International Journal of Recent Advances in Multidisciplinary Topics
Volume 2, Issue 10, October 2021
https://www.ijramt.com | ISSN (Online): 2582-7839

Electric Hybrid Vehicles: Scope, Challenges and Applications

Mayuresh Pramod Kulkarni[1*], Pranav Vijay Khade[2], Prathamesh Vijay Killedar[3], Shreyas Anil Patil[4], Shreerag Suranshu Kulkarni[5], Shivam Sanjay Mandlik[6], Pravin Gosavi[7]
[1,2,3,4,5,6]*Student, Department of Mechanical Engineering, KIT's College of Engineering, Kolhapur, India*
[7]*Assistant Professor, Department of Mechanical Engineering, KIT's College of Engineering, Kolhapur, India*

***Abstract*: This paper consists of working of hybrid electric vehicles (HEVs). This comprises of evolution of hybrid vehicles in recent years, different types of alignment in HEVs, challenges faced in early years before it hiked into the market. This also focuses on its various applications which will be useful in future car market and future trends. This descriptive outline is based on opinions of researchers and automotive companies.**

***Keywords*: Hybrid vehicles, evolution, alignment, future trends.**

1. Introduction

In early years, internal combustion engines were leading automotive market but first vehicle, a tricycle powered by battery, was developed but with the advancements in ICE's, pure electric vehicles (PEVs) were left behind since 1930s due to limitation of storage batteries at that time. It was clear dominance of ICEs over the EVs over a century. If all the vehicles are powered by internal combustion engine until 2040, the petrol and diesel will be depleted quickly and problems due to global warming will increase. This has led to interest in more efficient and environmentally means of transport. So, at this time more automotive companies are inclined towards EVs, some tried to combine the both ICE and EV by making it hybrid (HEV). Hybrid vehicle combines conventional IC engine and electric motor that assists the engine while accelerating. Sometimes they work separately and sometimes they work together. The HEVs has the rapid refueling characteristics and energy saving capabilities due to combine power source. This paper has been divided into different sections, with span of areas being covered throughout. Starting from history behind HEVs, configurations and way in which HEVs work.

2. History

The competition between ICE and HEV began from early 19th century. Between 1890 and 1905 ICEs, EVs were all promoted in the US and UK. EVs were leading the market in the United States at that time, mainly due to contribution of Tesla and Edison. The first HEV was made in 1898 but Henry ford actuated mass production of IC engines making them widely available and affordable. Smooth coordination between motor and engine was not possible because controls were totally mechanical. So the production of HEV's does not lasts for course of time. The HEV did not become widely known until the launch of Toyota Prius in Japan in 1997 and then release of Honda Insight in 1999 while it was recognized as unnecessary due to the low cost of gasoline, as worldwide increase in the price of petroleum made many automakers to launch hybrids in the late 2000s, from that time HEVs were perceived as a core segment of market of the future. The number of probable designs and HEVs have been increasing since the arrival of them onto the world market in 2000.The interest have been increased along with law-making has put forward clean and efficient transportation not only a vision for the future , but one for today.

1) How they work

These vehicles combine an IC Engine with a battery and electric motor and a generator. It recovers energy via regenerative braking. Sometimes gas engine does all the work, sometimes it's the electric motor, and sometimes they work together. The electric motor can get full operation at low speeds so, gasoline engines are provided to give average power requirements. The onboard electronic system on vehicle can decide whether the IC engine, motor or both are the most effective to use at that time. In parallel configuration , where both gasoline engine and motor can assists power to the transmission where as in series configuration IC engine never contributes directly for transmission. Regenerative braking converts wastage energy from braking into electricity and store it in the battery. Whenever brakes are applied, while the vehicle is slowing down or at idle condition, power goes back to the battery that is called regenerative braking, energy of rotation of wheels while we break works like a power station, feeding the battery so it can store the charge for the future use.

2) Configurations of HEVs

In HEVs propulsion energy is accessible from two or more types of energy converters and at least one delivers electrical power. Based on this there are many types ,ICE and battery ,capacitor and battery and battery and flywheel .But , traditionally HEVs are classified into three types ,they are as

*Corresponding author: mayuresh.kulkarni.kitcoek@gmail.com

follows:

1. Series HEVs
2. Parallel HEVs
3. Series Parallel HEVs

3) Series Hybrid Vehicles

It comprises of ICE, Power converters, Generators, motor and battery. In this type, proportion of vehicle is by battery powered electric motor. The electric energy for the batteries comes from an onboard energy source like the internal combustion engine. IC engine never powers the vehicle directly so because of this the vehicle can be moving with or without the IC engine running. The main purpose of engine is just to charge the batteries of the vehicle. So it is design to operate at most efficient speed and load. The advantage of Series hybrid design is that no transmission, clutch or torque converter is needed. The great example of this variant of vehicle is Chevrolet Volt. A big disadvantage of this the series hybrid vehicle is that they are entirely dependent on battery power, they also have much lesser performance than normal IC engine vehicles while driving up slopes, to compensate for this bigger and more powerful motors should be used , this further increases the weight of vehicle which decreases the total range of vehicle. As energy is being converted from mechanical energy into electrical energy, total system efficiency is reduced.

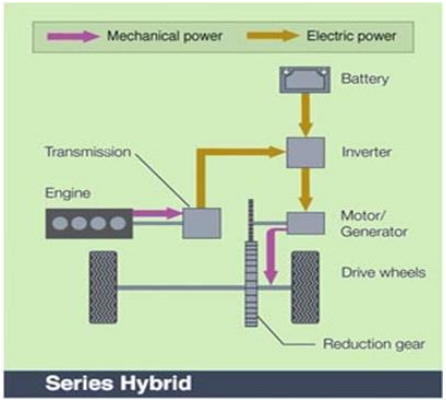

Fig. 1. Series Hybrid

4) Parallel Hybrid Vehicles

To overcome the drawback of series hybrid vehicles, parallel hybrid vehicles were created. Where the multiple propulsion sources can be combined and used or only one of the energy sources can be used. The vehicles using parallel hybrid design can be powered either by IC engine alone or by electric motor alone. The vehicle can also be powered by a combination of engine and electric motor. In most cases the electric motor is used to assist the IC engine, because of this size of electric motor and engine can be significantly reduced. Parallel HEVs have potential to switch off the engine and run purely on the electric motor for short period of drive. The output from IC engine in parallel HEV can be controlled by continuously variable transmission (CVT) with a three-way gearbox and clutch. Parallel hybrid vehicle is also capable of regenerative braking and internal combustion engine can also act as a generator for supplemental braking.

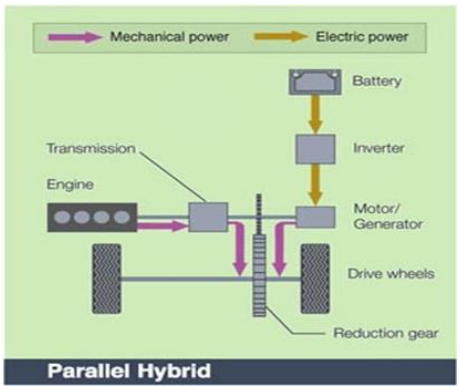

Fig. 2. Parallel Hybrid

5) Series-Parallel hybrid vehicle

The series-parallel hybrids combine the functionality of both a series and a parallel design. In this type of hybrid vehicles the engine of the vehicle is used to charge the battery and also move the vehicle forward. They are also called Power split hybrids and have advantage of combination of series and parallel characteristics. So their overall efficiency is more, as series hybrids are more efficient at low speeds and parallel hybrids tend to be more efficient at high speeds. But, cost of series-parallel hybrid is more than pure parallel hybrids. This type of hybrid configuration is used in the Toyota Prius this is the reason why the Prius has a really good mileage of 28 kilometers per liter, other examples include models of General motors, Ford, Nissan and Lexus. Means a series-parallel hybrid model permits the vehicle to control in electric motor mode only or in combination with the internal combustion engine. In it characteristics of both series and parallel type hybrid electric vehicle are used, even though the complexity of structure leads to more cost of manufacturing technologies, but it is more flexible in control. Many modern hybrids adopt this system.

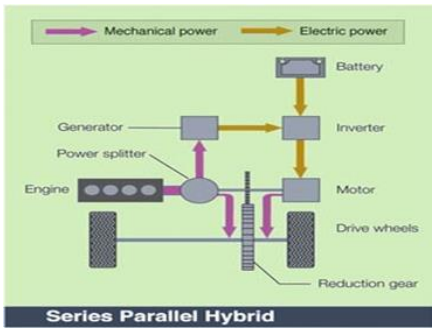

Fig. 3. Series Parallel Hybrid

3. Opportunities in the Market

The growing impact of global warming has led automotive industries to develop interest in HEVs. The emissions of CO2 from vehicles are a big problem, so this awareness of the emissions has cause the government to implement strict emission rules. The increasing stringency in emission regulations has forced automotive industries to manufacture hybrid and electric vehicles. HEVs has put forward many opportunities for growth in the markets of developing countries because of support and initiatives from government incentives

in tax rebates, sales and manufacturing. The Indian government is offering incentives of approx. USD 446 on the purchase of HEVs. The government of Brazil is encouraging the purchase of HEVs like hybrid electric, CNG hybrid and plug-in-hybrid by decreasing the taxes. The Mumbai Metropolitan Region Development Authority (MMRDA) has offered a contract to Tata motors for supplying 25 Star bus Diesel Series Hybrid Electric Buses. Faster Adoption and Manufacturing of Hybrid and Electric vehicles (FAME) started by government of India which provides incentives for buying hybrid vehicles. This scheme provides incentives to the electric and hybrid vehicles ranging from Rs.1800 to Rs. 29000 for scooters and motorcycles and Rs.1.38 Lac for cars.

4. Future Trends

According to references, by 2040 55% of all new cars will electric.

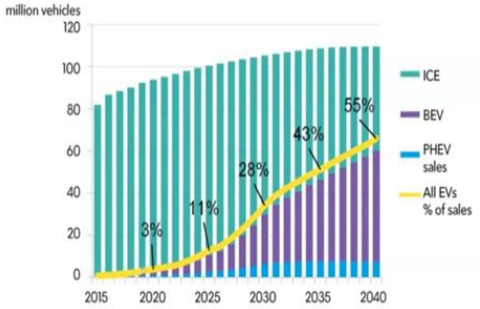

Fig. 4. Future Trends

This means large amount of contribution coming from battery pack. According to Lithium ion battery survey in 2016 price of Lithium ion battery dropped 73% since 2010.It is due to technological improvements and economies of scale. The major reason for bringing down the prices is fierce competition between major manufacturers across globe. Also the people are investing money in researching batteries and they are coming up with breakthroughs.

1) Lithium ion Battery Survey

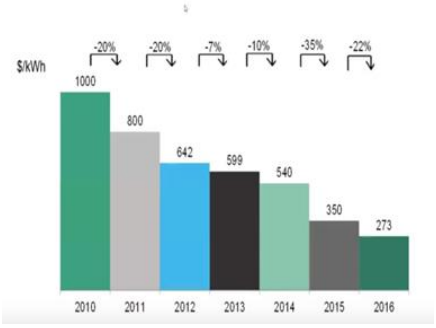

Fig. 5. Lithium Ion Battery Survey

Metals and material demand from Li-ion packs, demand for materials is increasing, because it goes hand-in-hand demand for hybrid vehicles which require a battery pack.

2) Material survey

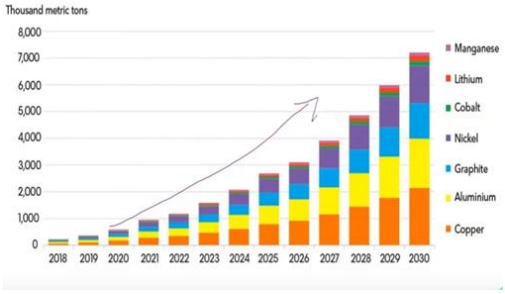

Fig. 6. Material Survey

According to experts, the hybrid fuel cells are the expected energy for the future. However, the low autonomy, difficult storage and required energy in order to obtain the liquid hydrogen stage make very expensive use of this technology. So only feasible technologies in future are two: EV and HEV. The hybrid vehicle within the simulation model however it might be interesting to review the strength and emission formation with bio fuels like Ethanol or DME, once utilized in a hybrid vehicle. Cylinder deactivation is employed during this study to adapt the ICE power for low power requirements. Another answer can be employing a little ICE that's powerfully overcharged to handle power necessities. Engine might therein case be supplied with electrical turbo charger.

5. Challenges

The increasing demand for battery electrical vehicles (BEVs) and Fuel Cell Electric Vehicles (FCEVs) are one amongst the main challenges for the expansion of hybrid vehicles .There are several models and kinds o BEVs like hatchbacks, SUVs and sedan in the passenger car segment. The advantages of FCEVs are a fast refueling, high driving range, zero emission of greenhouse gases and noiseless operation. These advantages completely impacting the demand for FCEVs. Moreover governments are taking initiatives and promoting fuel cells for transportation, which might boost the demand for fuel cells within the automotive and transportation sectors. The challenge faced by hybrid vehicle market is high price. Hybrid vehicle like plug -in hybrid has battery as its central element. The battery will increase the price of vehicle, making it costlier than diesel and gasoline powered vehicles .The cost difference is because of components like battery and regenerative break price. However, there has been major decrease in the price of batteries within the past few years. Also, R&D operations are carried out by battery manufacturers to decrease the cost of batteries.

Generally hybrid vehicles have components like converters, generators, IC engine and battery which require maintenance; It uses more parts than conventional IC engines so require more maintenance. There is lot of possibilities of failure and a typical mechanic is not trained to properly fix the vehicle and solve the problems in engine. Hybrids have a way higher risk of exploding (Depending on the impact of vehicle) as it is a mixture of ethanol and gasoline, both of which are extremely flammable. HEVs has multiple energy system, main challenge

of HEV is a way to optimize power flow to get low emission or best fuel economy at lower price, that is `usually referred to as energy management problem

6. Applications

A. Models of HEVs

1) Toyota Prius

Prius was the first HEV in the world, developed and manufactured by Toyota in 1997. Prius uses series-parallel configuration which allows engine to be at its very efficient speed range and load for most of the time. Prius can achieve 22.4 kmpl in city, 19.4 kmpl on the highways and can go from 0 to 100 kmph in 14 sec. It is highest in all electric mode of any vehicle rated by EPA.

2) Honda Civic

Civic is parallel hybrid vehicle, first released in the United States in 2002.It has Honda's Integrated Motor Assist (IMA) system. This system is motor generator system which powers the vehicles. This system combines 1.3 liter, 4 cylinder petrol engine with 10 KW ultra thin permanent magnet electric motor. Civic can achieve 21.93 kmpl in the city and 19.78 on the highway. It was the first hybrid car launched in India.

3) Hybrid Electric Train

This train came in service in 2018-19.It was developed by the Department of Science and Technology's Metals industry research and development center. Train has 260 lead acid batteries to run the train and operate its CCTV systems, automatic doors and air conditioning. It also uses regenerative braking system

4) Military Application

Military applications contains both direct vehicular applications that are associated to vehicular propulsion and indirect applications in the sense of using electrically operated arms or interfacing with the vehicular electrical system to make a micro grid to provide power to a military base. One of the vital reason for considering HEVs for military application is that the cost of fuel. Transporting fuel to the field through risky routes and over long distances will raise the value of fuel considerably.

7. Conclusion

The expansion in market potential of HEVs is powerfully influenced by emissions norms implemented by governments of developing countries. Therefore, stringent emission norms are common in countries where Hybrid Vehicles have been successful. This paper has given overview of all concepts implemented in HEVs. The main aim of these concepts is to enable better fuel efficiency of the commercial cars as well as to decrease global warming. Also this paper focuses on main challenges; future trends on HEVs.HEV will meet consumers need presently and can grow in quicker rate. FCEV has long-run potential for future main stream vehicles because of zero emission and comparable driving range with IC engine vehicles and also main challenge of HEV is the way to optimize the multiple energy sources to get best fuel economy or low emission at lower price, and this gives edge over the HEVs. Besides completely different ideas of the propulsion systems, near future can provide a solution which of this electric fuel-cell or hybrid technology will be dominant.

References

[1] https://www.hindawi.com/journals/ijvt/2011/571683/
[2] http://autocaat.org/Technologies/Hybrid_and_Battery_Electric_Vehicles/HEV_Types/
[3] https://en.wikipedia.org/wiki/DOST_Hybrid_Electric_Train
[4] https://www.marketsandmarkets.com/Market-Reports/hybrid-vehicle-market-159441728.html
[5] https://en.wikipedia.org/wiki/Toyota_Prius
[6] https://core.ac.uk/download/pdf/41785444.pdf