Optimal Strategies for the Development of Electric Vehicle (EVs) and Hybrid Electric Vehicles (HEVs) – A Review

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Abstract**—** Traditional vehicle systems are being phased out in favour of more contemporary options such as hybrid electric vehicles (HEVs), fuel cell-powered automobiles, and electric vehicles. As a consequence of these advancements, the future of this industry will look quite different. As technology advances, there will be a greater demand for technical research and development. Because of the nature of this research, it is feasible that it will give an optimum design approach for the various configurations tested. Following a brief overview of the essential technologies, this article delves into the various vehicle layout options. The last part shows how real-time modifications are done depending on how different parameters impact the performance of the vehicle.

Keywords**—** *Design techniques, component's, EV – Electric Vehicle, HEV – Hybrid Electric Vehicle, Fuel Cells, Battery System.*

I. INTRODUCTION

Transportation is expanding rapidly because the global population is expanding at a rate that is directly proportional to people's mobility [1]. Presently, all governments across the world have deployed and implemented a number of rules and regulations in the automotive industry to battle air pollution and fuel consumption. On the other side, consumers are looking for improved amenities like climate control, audio systems, and safety features. [1]

The automotive industry is shifting toward electrical components in their cars in order to achieve both goals, reducing air pollution while still meeting the needs of consumers. This is accomplished, in part, by replacing mechanical and hydraulic components with electrical ones. As a result, the cars themselves are lighter, and aerodynamics are given more consideration in order to cut down on fuel use. [1]

Unlike conventional automobiles, which can only run on gasoline, which isn't exactly in plenty. However, with electric automobiles, the battery is the power source that takes energy to charge, but the problem is its feasibility. The good news is that if greater attention is paid to vehicle design, where the design as a whole is optimised to get the greatest outcomes, this problem may be resolved.

In contrast to the increase in electric vehicle design features that has occurred to meet customer demand, the engine model of conventional automobiles has evolved little in the last century. This page delves further into the major components' design, including topics like the model's battery type, the components' many types, and its architecture (including size) [2]. For this reason, the architecture of an electric vehicle remains the same even if the system design incorporates several factors, each of which has its own influence. The best designs prioritise both improved fuel economy and enhanced vehicle performance.

The major purpose of this study is to examine and appraise the state-of-the-art of optimal design for electric and hybrid vehicles. Hybrid electric vehicles (HEVs) and electric vehicles (EVs) are the focus of this study, which also describes and formulates a structural framework for comprehending optimality in the case of these technologies and highlights the core of these technologies that underpins all previous research in these areas.

First, it's important to define what it is that we mean by "new electrical technology." For example, whereas pure electric vehicles rely only on batteries for power, hybrid electric vehicles combine power from an internal combustion engine and a battery to achieve linear operation.

II. CONFIGURATION

Here, we take a close look at the many architectures, parts, and designs that go into making HEVs, battery cars, and fuel cell vehicles work. In most cases, a hybrid electric vehicle(HEV) consists of an internal combustion engine (ICE) and an electric motor, which may be linked in one of four different ways (series, parallel, series-parallel, or complex) depending on the task at hand. Similarly, the electric motor is the only moving part in battery-powered vehicles; no other designs or electrical networks are used. Vehicles powered by a fuel cell are quite similar to those powered by batteries. In terms of physical design, a PHEV is quite similar to a HEV, however the functional operating model is different. All the various car setups are summarised in Table 1.

Table 1: Configuration of the vehicles

Types	Components	Topologies	Power source
Hybrid Electric Vehicles	-Electric motors -Internal Combustion Engines	1)Series 2) Parallel 3) Series-Parallel 4) Complex hybrid	-Electrical Grid -Gasoline stations
Battery Electrical vehicles	Electrical motors	None	Electrical grid
Fuel Cell vehicles	Fuel Cell	None	Hydrogen
PHEV	-Electric motors -Internal Combustion Engines	None	-Electric motors -Internal Combustion Engines

A. Setup in a Series: Change from mechanical to electrical kind of energy. An internal combustion engine (ICE) serves as a generator in this setup, complementing the battery that serves as the primary power source [3]. Here, the ICE just serves as a power generator while the electric motor is directly linked to the wheels. The converted electrical energy may be stored in the battery or sent straight to the wheels by going around the battery, as shown in [3]. When the battery's charge drops below the makers' suggested minimum contained value [3, the ICE is activated]. Since series HEVs use three different propulsion systems—electric motor, internal combustion engine (ICE), and generator—their sizing is challenging [3].

B. Setup in parallel: Transformation from mechanical to electrical form. These systems rely on a combination of batteries and internal combustion engines (ICE) [3]. The propulsion in this case comes from a combination of an electric motor and an internal combustion engine (ICE) that is wired directly to the wheel. Parallel HEVs are easy to size since they only need two propulsion systems, an electric motor and an internal combustion engine (ICE) [3].

C. The Series-Parallel Setup: Multiple HEVs set up in either a series or a parallel arrangement. In this setup, the ICE and wheels are connected mechanically in a manner similar to the series arrangement, while a generator is used in a manner analogous to the parallel configuration [3, 4]. Sizing series-parallel HEVs is difficult because of the complexity introduced by the multiple powertrain options [4]. Electric intense configurations, in which electric motors serve as primary power sources, and engine intensive configurations, in which internal combustion engines (ICE) serve as primary power sources, are two examples of the compound kinds of activities [4].

D. Assembly Complexity: The operation of complex HEVs is identical to that of a series-parallel arrangement. Power can flow in both directions in a complicated HEV, but in a series-parallel system it can only flow in one way [3]. The series-parallel architecture makes scaling sophisticated HEVs a lot trickier.

E. Powering the Future with Fuel Cells

DMFC – It is possible to store liquid fuel in a direct methanol fuel cell [4]. Low power density despite a high energy density. Forklifts and other specialised vehicles make extensive use of AFCs (Alkaline Fuel Cells) [4]. Equipment costs are lower than those of competing technologies. However, to solve the man issue, we must utilise pure hydrogen since carbon dioxide poisoning lowers the efficiency of the fuel cell.

SOFC – The primary function of a solid oxide fuel cell [4] is to provide auxiliary electricity for appliances like automobile air conditioners and home heaters. However, their high working temperature of about 800 to 1000 degrees is more than compensated for by their lengthy starting time.

PEMFC – Proton Exchange Membrane Fuel Cell [4] Compact design. Meeting urgent production requirements is feasible. The biggest drawback is that the vehicle's efficiency is diminished due to the increased levels of carbon monoxide pollutants.

The car industry is now making use of the various fuel cell technologies discussed above. There are pros and cons to each of these technologies, therefore they may be combined with others in certain contexts. To that end, we'll look at the many fuel cell technology hybrids, each of which has its own advantages and disadvantages, as described above.

A. hybrid fuel cell/battery system: The most typical HEV setup. Low energy consumption from the battery and electric motor means that the SOC of the battery may be kept constant [4]. The upkeep of batteries is quite costly.

B. Battery and supercapacitor-equipped fuel cells: Similar to the preceding generation, but with super capacitors instead of conventional range boosters [5].Through the use of high-power-density super capacitors in tandem with high-energy-density batteries, we are able to significantly improve the charging and discharging capabilities of the batteries and extend their useful lifespan.

There are a few key characteristics of fuel cell based cars [5] that set them apart from HEVs, including fuel adaptability, direct energy conversion, and little air pollution.

C. Hybrid Electric Vehicle Plug-In Arrangement: The introduction of PHEVs, or plug-in hybrid electric vehicles, has been a game-changer for the HEV market and the automotive industry as a whole.

The primary reason for this is the PHEV's unique method of operation; although a regular PHEV functions similarly to a HEV, it also has an extra feature not found on a HEV: a longer All Electric Range (AER) [6].

A plug-in hybrid electric vehicle (PHEV) is an alternative to the conventional hybrid vehicle (HEV) that employs a mechanical power train for propulsion but adds an electric motor on top. Therefore, the user may experience zero-emissions, fuel-free driving for a short distance before the battery's State of Charge (SOC) [6] drops too low. Thereafter, the PHEV switches to its HEV mode of operation. However, the capacity of the electric storage system is the only determinant of the All Electric Range (AER).

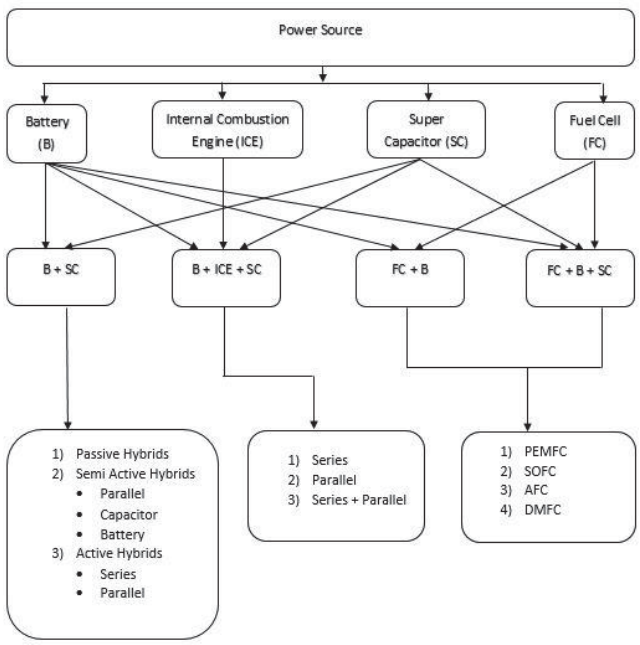

Fig 1: HEV, FCV, and BEV Setup

Auto industry examples of electric and hybrid electric vehicle powertrains are shown in Figure 1 below, along with examples of their numerous configurations and technical specifications.

III. EFFECT ON VEHICLE EFFICIENCY

Increased fuel economy and less pollution are the key motivations for the development of hybrid electric cars. The following considerations are meaningless, however, if the vehicle's primary characteristics are disregarded. The vehicle's performance must be maintained throughout its operating life cycle, and this necessitates a substantial, functional Energy

Management System (EMS) [7]. This EMS, however, is much more crucial in the perfect HEV design, since it regulates the whole energy flow before it reaches the wheels. Depending on the specific configuration used, a typical HEV's [7] EMS will adopt one of many different ways to deal with changes in the energy flow that occur as a result of the vehicle's operation. The EMS's control methods have been the subject of a large body of published research, and these methods are always being tested and refined to better serve the system. In layman's terms, EMS governs the vehicle's modes of operation in real time and during the idling phase.

Rules-based control strategies and optimization-based control strategies are the two main kinds of control methods utilised in a HEV [7].

There are two subsets of the rule-based control strategy: 1) the Fuzzy rule-based approach, which use the nonlinear and fuzzy logic qualities to make choices based on performance. 2) Deterministic rule-based control technique, where a lookup table is constructed using a heuristic function that includes characteristics such as fuel consumption, pollution level, and even human knowledge to evaluate the vehicle's performance.

One sort of optimization-based control strategy [7] is global optimization, which is most often employed in fuel-cell-powered HEVs, and the other is Bellman's optimality principle, which is used to the evaluation of vehicle performance. The difference between global and real-time optimization lies in the cost function used to measure fuel consumption and the long-term viability of electrical energy stored in the storage system.

A. Efficient Development of Hybrid Electric Vehicles

The challenges of HEV architectural design, both single- and multi-modal, were addressed in [2]. All aspects of a hybrid car's battery pack have been taken into account. It was looked at how changing the gear ratio might affect the gas mileage. At first, we experimented with several architectures while keeping the sizes the same, and later, we optimised both the architecture and the sizes together. A generic algorithm was used to achieve the best possible design.

In [8], several engine, battery hybrid, and combinations were taken into account to maximise economy and driving comfort. Using a dynamic programme, an ECMS, and design criteria including feasibility, drivability, size, and transmission efficiency, only two of 1152 alternatives were selected. Parameters of hybrid vehicle designs are optimised in [14–20].

B. The Improvement of Electric Vehicle Layout

The literature [21–27] discusses the optimization of various electric vehicle design parameters, with a special emphasis on a battery super capacitor ESS, and [9] addressing this topic specifically. To get the most out of both the super capacitor and the battery, we employ something called the "degree of hybridization" (DH) to regulate the two systems' interactions. Models of the battery electric vehicle's motor, power electronics, and propulsion systems are fine-tuned to get the desired level of performance [10]. (BEV). The cost effectiveness of batteries is optimised by [11]. The goal of [12] is to optimise the design of an FCHV. Consideration is given to the design issues of the fuel cell stack, such as the optimal number of cells and the size of the active cell area. Records are kept on the current and voltage in the stack as well as the amount of hydrogen used. Overall system efficiency was shown to be enhanced by both decreasing fuel cell system size and increasing hybridization levels.

With its ability to minimise pollutants while preserving mileage, HEVs have become a practical alternative to conventionally powered vehicles. It has better range than electric vehicles and more adaptability in terms of component size [6]. Storage, rather than the engine, is seen as the primary source of PHEVs, elevating them above HEVs. This makes them more eco-friendly than HEVs in terms of fuel efficiency and pollutant output.

Nevertheless, ICE-reliant PHEVs and HEVs are expected to be eventually replaced by EVs. The EVS's short range of operation may be improved upon by combining them with larger storage units or fortifying them with range extenders. Either a fuel-based device, such as a fuel cell, or a renewable energy unit, such a super capacitor, may be included as an option [13]. With the right EMS, energy sources may be utilised efficiently, and the vehicle's performance can be maximised in any scenario.

CONCLUSION

Since the fossil fuel problem is so obvious, alternative solutions are being examined, but these new approaches also come with their own set of challenges. Different configurations, topologies, and design parameters for hybrid electric vehicles (HEVs), battery electric vehicles (BEVs), fuel cell vehicles (FCVs), and plug-in hybrid electric vehicles (PHEVs) are discussed in this paper, along with their respective advantages and disadvantages, as well as the applications for which they have proven most useful. However, more work has to be done on the research and development front to make the system far more reliable in real time and eliminate all these issues.

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