Industrial Engineering Journal
ISSN: 0970-2555
Volume : 51, Issue 10, October: 2022

ANALYSIS ON AN AUTOMOBILE BASED HYBRID ELECTRIC VEHICLE SYSTEM BASED ON VARIOUS INTERNAL COMBUSTION ENGINE

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ABSTRACT

Increased environmental impact from the fast consumption of fossil fuel has provided a significant drive for the creation of more fuel-efficient automobiles. Having matured from their embryonic stage, hybrid electric vehicles (HEVs) are showing signs of being a viable solution to the critical existential threat to Earth. Higher efficiency vehicles (HEVs) not only help drivers save money on gas by getting greater mileage and producing fewer harmful emissions, but they also cushion drivers and passengers from the financial blow of steadily increasing gas costs. The electrification of powertrains is a tried-and-true response to environmentalists' worries about dependence on non-renewable fuels and greenhouse gas emissions. Hybrid electric vehicles, which bridge the gap between conventional internal combustion engine vehicles and pure electric vehicles, are gaining market share and garnering a lot of attention from researchers in both the private and public sectors. An integral part of hybrid powertrains, the internal combustion engine affects vehicle performance significantly. There has been a lot of work done in recent years on engine technologies tailored to hybrid electric vehicles. It is crucial to study the engine's dynamic features through testing that mimic the vehicle's road running mode. The electric eddy current machine of an automotive engine test stand mimics the loading conditions of being driven on the road. Recommendations from a technological perspective all the way up to a powertrain perspective are presented in response to challenges and issues related to system complexity, restricted operating conditions, controls, cost, safety, etc. To inspire further study in this area, several potential avenues for future research are given.

1. INTRODUCTION

People and products can move freely thanks to well-oiled transportation system. Transportation via road accounts for 75% of all transportation energy use, followed by rail, marine, and air. Because of the auto industry's vital position in global economic expansion, its effects are felt by everyone everywhere. Since ICEs are the norm in the transportation sector, it is responsible for 25–30% of all manmade greenhouse gas emissions [1]. ICE operates through the combustion of fuel, which produces a number of gases including CO2, NO2, NO3, and CO [2]. These gases contribute to environmental deterioration through the greenhouse effect and have negative health effects for humans. The transportation sector is working hard to develop vehicles that can function on non-conventional energy sources as a means of overcoming this obstacle. In an attempt to solve this problem, people in 1881 built the first electric vehicles (EVs), which relied solely on a battery to move. Due to the lack of an internal combustion engine (ICE), the range of these cars was severely limited [3]. For those who want the best of both worlds, the power of an internal combustion engine (ICE) and the zero-emissions of an electric vehicle (EV), hybrid electric vehicles (HEVs) were developed. The state of charge (SOC) of the battery is maintained throughout the journey in HEVs, resulting in superior fuel efficiency than that of ICE-based vehicles. Plug-in HEVs (PHEVs) were conceived of as a potential solution to the problem that CS mode's charging efficiency is dependent

http://doi.org/10.36893/IEJ.2022.V51I10.126-132

on regenerative braking and fuel. Unlike HEVs, plug-in hybrid electric vehicles may also be charged from standard electrical outlets. The electric motor (EM) is the major source of power in a PHEV, with the internal combustion engine (ICE) providing backup. If the battery state of charge (SOC) drops below a certain level, the PHEV switches to operating like a conventional HEV, with the ICE serving as the primary power source. Most of the time, PHEVs will operate in charge depletion (CD) mode, where the SOC is gradually drained until it reaches a predetermined minimum. PHEVs have the potential to connect to the grid, increase the all-electric range, and better the air quality in their immediate surroundings.

Allowing the battery to be charged while the HEV is in use is yet another strategy for increasing its electric range. The advent of solar-powered HEVs (PVHEVs) allows for the constant charging of batteries using solar energy, resulting in reduced pollution caused by the use of gasoline.

Battery life and cost are two major issues for hybrid cars. Several different types of HEV battery compositions have been tested in the past, but lithium-ion variants have shown the most promise. There are three tiers of battery pack integration for automobiles: (1) individual cells, (2) modules made up of multiple cells, and (3) battery packs made up of packs. The battery needs to be able to sustain millions of transitory shallow cycles over the vehicle's lifetime and provide high power for brief periods of time. A battery's runtime and lifespan can be improved by connecting it to an ultracapacitor (UC), which allows for a greater charge/discharge rate and lower internal resistance, therefore producing less heat and improving dependability. As a result of UC, the efficiency of the cycle is raised to the range of 90-100% [4]. When used together as part of a HESS, batteries and UC are more effective at storing energy than each component alone.

High demands are placed on test circumstances of engine dynamic feature research [11] due to the fact that automobile engines frequently operate in the mode of variable load and variable rotational speed. Driving wheel is put on the roller that is coaxial with electric eddy current machine, and when automobile engine drives the wheel to revolve, friction force causes the roller to rotate. This is a test stand that simulates the road operating mode of an automobile engine. In order to imitate the stress that the road puts on an automobile's engine, an electric eddy current machine's excitation current control causes the roller to apply a countervailing torque to the wheel [12]. When the engine is under load, the output power can be measured with the use of a transducer, a signal processing circuit, and some testing software.

2. LITERATURER EVIEW

Consequences, such as rising fuel prices and strict pollution rules, have been placed on the public and vehicle manufacturers as a result of the steady depletion of global fossil resources and serious greenhouse gas emission issues (Horrein et al., 2016). Extending current energy consumption patterns to 2050 increases global energy demand and emissions by 70% and 60%, respectively, compared to 2011 levels, as reported by the International Energy Agency (IEA) (Anon, 2014).

In order to make the change from traditional petroleum-based vehicles to cleaner low-carbon vehicles, many organisations and businesses have devoted time and resources to research and projects on powertrain electrification in recent years (Al Khoury and Bou Nader, 2021).

Electrified vehicles, such as fully electric vehicles (EVs) and hybrid electric vehicles (HEVs), are developed and popularised in an effort to reduce or eliminate the use of fossil fuels in transportation (Biswas and Emadi, 2019, Anselma et al., 2020).

Higher energy efficiency and zero emissions from the tailpipe make full EVs the future of the auto industry. However, the largest obstacle to their market adoption and extension are worries about safety, cost, durability, and range (Alkhulaifi et al., 2019).

Combining the best features of ICEVs (internal combustion engine cars) and EVs (electric vehicles), HEVs offer a practical compromise by reducing energy consumption, lowering pollutants, and increasing mileage (M. Sabri et al., 2016).

http://doi.org/10.36893/IEJ.2022.V51I10.126-132

From the simplest start-stop systems to full hybrid vehicles, the market has seen a wide range of hybridization ratios represented by dependable vehicles (Van Mierlo et al., 2006).

Parallel to this evolution, a wide variety of HEV subtypes and layouts have been created. The plug-in hybrid electric vehicle (PHEV) is the most environmentally friendly HEV variation because it can go far on battery power alone thanks to its larger battery and the ability to charge externally from the electric grid (Guo et al., 2019).

Range-extended electric cars, often known as series HEVs, are another subset of hybrid electric vehicles. Only battery power is used for propulsion in REEVs, therefore they function similarly to EVs in most situations. When the power supply becomes low, a range extender kicks in and begins recharging the battery through an internal combustion engine (ICE) powering a generator (Xiao et al., 2021).

Due to the inclusion of a second propulsion system, HEVs offer greater engine operating versatility than ICEVs. One or more electric motors (EMs) and an energy storage system (ESS) are common components of a HEV's powertrain (aatay Bayindir et al., 2011). Using varied engine topologies and energy management systems, HEVs can accommodate a wide range of load needs thanks to their many energy sources (Banjac et al., 2009). Previous literature reviews have discovered, categorised, and extensively examined existing hybrid powertrain architectures (Tran et al., 2020). Fuel consumption minimization (Biswas et al., 2021), emission reduction (Hu et al., 2020), and battery life extension are just a few of the goals that have prompted extensive research into energy management strategy (EMS), which deals with the power distribution among power sources based on their own control rules (Anselma et al., 2021).

CLASSIFICATION OF HYBRID VEHICLE’S INTERNAL COMBUSTION ENGINES (ICE)

Vehicle hybrids The fuel used to power an ICE is another criterion for categorising ICEs. Specifically, it can be broken down into the following categories:

Type1. Compression engine powered by diesel and DiMethyl Ether (DME) blend;
Type 2. Engine with a spark plug;
Type 3. Hydrogen-powered, spark-ignition engine;

A. Compression Engine (Diesel) Fueled With Mix of DME - (Type 1)

A compression engine powered by a blend of dimethyl ether and diesel can achieve greater efficiency than one powered only by diesel. A fuel with a higher oxygen content, like DME, results in less soot being created during combustion. If DME is raised, soot emissions are reduced across the board. Adding DME increases NOx emissions over diesel at all engine speeds. It has been observed that the NOx emission has decreased due to the modification of the injection pressure, but not to the same extent as diesel. To lessen environmental damage caused by vehicle emissions, after-treatment systems for exhaust gases are needed. For this reason, this engine configuration is not recommended from an environmental standpoint.

B. Spark-ignition (SI) engine fueled with gasoline fossil fuel-(Type 2)

In this setup, standard SI engines can run on a 50/50 methanol/gasoline combination. This fuel mixture has decreased torque and power significantly, but improved the engine's thermal efficiency when braking. Increases in formaldehyde emissions are a downside of the methanol growth. Therefore, on the grounds of emissions and efficiency, this kind is likewise unsuitable for use in hybrid electric vehicles [6].

C. Combustion ignition engine fueled with hydrogen- (Type 3)

Hydrogen fuel in internal combustion engines is one aspect of a comprehensive plan to address air pollution and the depletion of fossil fuels. Today, hydrogen may be used as a fuel because to improvements in engine technology and related infrastructure. Hybridization, multi-mode operating

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techniques, varying operating parameters, and development in materials and engine design offer promising prospects for greater power density, higher efficiencies, and decreased emissions [7].

3.1 Low temperature combustion (Low temperature combustion (LTC))

In the past, meeting pollution standards required just in-cylinder tactics like intake boost, increased fuel injection pressure, appropriate fuel injection timing, exhaust gas recirculation (EGR), and enhanced combustion chamber design. In-cylinder methods and ATS are likely to collaborate to meet increasingly rigorous emission regulations. In spite of this, it is difficult to considerably enhance the ATS efficiency because of the expensive price, durability concerns, and extensive space required (Zheng et al., 2015). Thus, it is once again of importance to make further advancements in in-cylinder tactics.

The two most common types of internal combustion engines are spark ignition (SI) and compression ignition (CI), both of which have been refined over many years. Still, there are bounds to what may be achieved with either combustion theory. Common-rail diesel combustion (CDC) is used in CI engines, which is recognised for its great thermal efficiency but heavy emissions. Although SI engines produce less harmful byproducts, they are also less efficient (Agarwal et al., 2017). New combustion ideas that can produce clean and efficient combustion modes are in high demand under these conditions.

4. ARCHITECTURE OF HCI

Electric motor (EM), battery, convertor, internal combustion engine (ICE), gasoline tank, and control board are the primary parts of a hybrid electric vehicle. You can divide these parts into three classes:

Drivetrains—physically integrate the ICE power source and electric drive.

Battery/energy storage system (ESS)—emphasizes large or modest energy storage and power capabilities.

Control system—instructs electric systems/ICE and manages the HESS.

The size and method of integration of these parts allows for a wide range of vehicle configurations. Drivetrains often fall into one of three categories, according on how its components are connected: series, parallel, or power split. The mild/microparallel, parallel, series, power split, mixed, and through-the-road (TTR) hybrid architectures are described in [6].

The DC bus receives electrical energy from the power sources in a series HEV, and that energy is subsequently transformed into traction power [7]. The traction power in a fleet of parallel HEVs might come from either internal combustion engines (ICE) or electrical motors (EM), or from both. In order to power the HESS, the EM is put to use during regenerative braking [8]. The parallel mild HEV is highly recommended because it strikes an excellent balance between vehicle cost and performance [9]. High-performance hybrid electric vehicles (HEVs) are architecturally complex, including elements of both parallel and series design. Very similar to series-parallel hybrids, with the exception of the motor's power flow, which is bidirectional in complex hybrids but unidirectional in series-parallel HEVs. Design complexity is a drawback of complicated hybrids. In Fig. 1, we have a visual depiction of these building plans.

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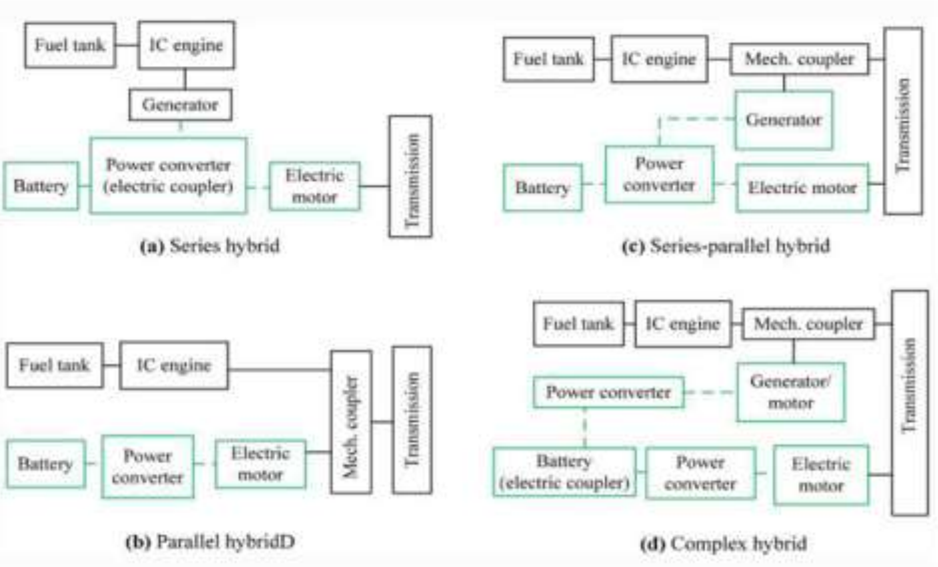

Fig 1: Various architectures of an HEV

Power-Hybrid Electric Vehicles (PHEVs) are mechanically comparable to conventional HEVs, with the exception of a sizable, on-board battery that provides both great energy density and efficiency. Combining CS and CD modes calls for a more sophisticated control strategy than that of a conventional HEV. Start-up in a PHEV is done in constant-discharge (CD) mode, and after the battery's state-of-charge (SOC) reaches a certain point, the PHEV switches to constant-current (CS) mode and stays there until it is parked and

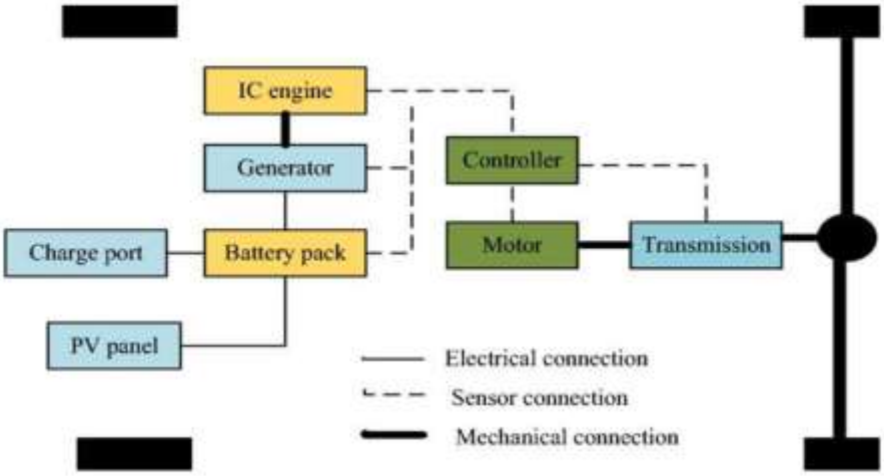

Fig 2: Block diagram of PVHEV

solar-powered hybrid electric vehicle (PVHEV) is structurally similar to a plug-in hybrid electric vehicle (PHEV), with the addition of a photovoltaic (PV) panel that recharges the vehicle's battery when the sun is shining. Algorithms called maximum power point trackers (MPPT) are used to get the most energy out of photovoltaic (PV) panels. Fig. 2 is a block diagram of a PVHEV system.

Atkinson cycle

Since the advent of the vehicle, the Otto cycle has been the preeminent thermodynamic cycle used in internal combustion engines. The real thermal efficiency of most Otto-cycle engines is only about 15%-25%. (Balmer, 2011). As a result, research into alternate thermodynamic cycles has been conducted in an attempt to boost the thermal efficiency of engines.

In order to increase the thermal efficiency of the engine, the Otto cycle was changed to create the over-expansion cycle (Hou, 2007). recharged.

http://doi.org/10.36893/IEJ.2022.V51I10.126-132

Atkinson and Miller cycles are two examples that have received a lot of attention recently. These cycles can be used in SI and CI engines, as well as hybrid and non-hybrid powertrains (Zhao, 2017). Another alternative cycle, known as the split cycle, divides the four strokes of the Otto cycle between two matched cylinders that are linked via a crossing passage. The intake and compression strokes are carried out by one cylinder, while the expansion and exhaust strokes are carried out by the other cylinder. It is a type of engine used by the Scuderi team that uses a split cycle (Naber and Johnson, 2014). It is important to note that the over-expansion action is made possible by designing a bigger displacement for the expansion cylinder, which is the greatest potential of split-cycle engines. Unfortunately, this design is hindered in its progression and market penetration by additional complexity and other technical problems (Finneran et al., 2020). Consequently, this section only discusses the over-expansion cycle (the Atkinson and Miller cycle).

CONCLUSIONS

One of the HEV's propulsion components, the engine, has a major impact on the vehicle's efficiency and emissions. High-performance hybrid engines can be developed via four different technological avenues: more refined combustion processes, cleaner fuels, more efficient operating cycles, and the recovery of wasted energy. Hybrid powertrain platforms have been the focus of a great deal of research into low temperature combustion, alternative fuels, the over-expansion Atkinson cycle, and waste heat recovery. This paper provides a complete evaluation of these four technological solutions, examining their advantages, disadvantages, and potential moving forward to ascertain the present state of research and shed light on future research opportunities.

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