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PARALLEL HYBRID ELECTRIC VEHICLE DESIGN, DEVELOPMENT, AND ANALYSIS

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ABSTRACT

Introduction: *In addition, fossil fuels are a limited resource that serves several purposes, including but not limited to the production of electricity, industrial activities, and transportation.*

Aim of the study: *the main aim of the study is to Parallel Hybrid Electric Vehicle Design, Development, And Analysis*

Material and method: *The layout of the drivetrain system will used to classify hybrid electric vehicles. Series, hybrid, parallel hybrid, and series-parallel hybrid will among the classifications.*

Conclusion: *The designer of an electrical system needs to be aware of power consumption and how to control it.*

1. INTRODUCTION

1.1 OVERVIEW

In response to growing environmental shame, consumer demand has shifted toward cleaner, more efficient electric automobiles. Fuel cell vehicles, hybrid electric vehicles, and autos powered by nonconventional energy sources have all advanced thanks to a focus on reducing pollution. More benefits, including lower emissions of carbon dioxide, are associated with the use of Hybrid Electric Vehicles (HEVs), which are powered by a mix of two or more energy sources. As the electric car accelerates, the drive motor's mechanical energy supplements the driving power from the internal combustion engine. Electric and hybrid electric vehicles (EVs and HEVs) include a regenerative braking system, which restores electrical energy during deceleration or braking. The effectiveness of a HEV is based on the power unit's ability to restore electrical power during braking/ideal running, to reduce electrical power and gasoline consumption, to generate the torque required by the driveline, and to counteract the ideal operation of the internal combustion engine and drive motors. Researchers have displayed a wide variety of EV and HEV topologies, each with the goal of improving the vehicle's environmental performance and lowering its operating costs.

It is expected that the passenger vehicle category will have seen the greatest growth in the Indian electric vehicle segment market over the past few decades, thanks to the proliferation of such automobiles in the fleet of shared portability firms, all thanks to the persistent efforts of the government of India and manufacturers of clean energy vehicles. The electric vehicle component market in India for bikes was led by the Original Equipment Manufacturer (OEM) division in 2019. OEMs are putting greater emphasis on the cycling market because the purchase rate for such automobiles is now higher than the rate at which parts are being replaced. During the studied period (2014-2019), the e-rickshaw segment led the Indian electric vehicle part market for three-wheelers due to the booming number of e-rickshaws in the major urban centres. In addition to being more convenient than auto-rickshaws, e-rickshaws are becoming increasingly common since they are less complicated to operate than pedal-based rickshaws.

1.2 HYBRID ELECTRIC VEHICLE

A hybrid electric vehicle (HEV) combines the advantages of conventional gas-powered vehicles with those of electric-powered ones. These cars are designed to improve upon the efficiency and performance of conventional internal combustion engine (ICE) automobiles, as well as address the shortcomings of pure electric motor-powered vehicles.

The term "hybrid electric vehicle" refers to a vehicle that combines an electric vehicle with a traditional internal combustion engine vehicle. Consequently, the vehicle is powered by both an internal combustion engine and an electric motor. It relies on both of these power plants to provide enough thrust to move the vehicle forward. According to the series or parallel connection, the power supply to the wheels is arranged in a different way. The vehicle is considered a series hybrid when the electric motor and ICE are wired in series, with the electric motor supplying the necessary mechanical power to turn the wheels. The car is considered a parallel hybrid when its electric motor and ICE are linked in parallel, with the result being that the wheels get mechanical power from both sources.

Liquid gasoline powers the ICE in a HEV, while batteries power the electric motor. By tuning the electric motor's torque and speed to work in tandem with the ICE, fuel consumption may be reduced. As a result of having two different types of propulsion, it avoids the problems associated with only electric vehicles.

2. LITERATURE REVIEW

Maddumage, Waruna et al., (2019). Hybrid-electric technology for automobile applications focus on improving emissions and fuel consumption. Therefore, the fusion of hybrid technology to existing conventional vehicles is an economic opportunity with social and environmental advancements. However, the introduction of electric machine(s) into traditional automobile powertrains has significantly increased its design complexity, thus challenging design capabilities of engineers and original equipment manufacturers (OEMs). The development of hybrid powertrain systems is a design optimization problem with multiple constraints and objectives. Over the years, various hybrid architectures have been developed to find the optimal design approach in developing an efficient automobile powertrain. This work presents a review of existing design approaches and design optimizing methods for converting conventional powertrain to a hybrid-electric system. In addition, an overview of different hybrid electric powertrain configurations beginning with conventional classification (series, parallel and series-parallel configurations) to modern, advance configurations; Hybrid powertrain modelling approaches (forward and backward modelling); component sizing and power management strategies used in designing hybrid-electric powertrain systems are elucidated.

Bai, Fan et al., (2019). This study investigated the matching designs between a power integration mechanism (PIM) and transmission system for single-motor parallel hybrid electric vehicles. The optimal matching design may lead to optimal efficiency and performance in parallel hybrid vehicles. The Simulink/Simscape environment is used to model the powertrain system of parallel hybrid electric vehicles, which the characteristics of the PIM, location of the gearbox at the driveline, and design of the gear ratio of a gearbox influenced. The matching design principles for torque-coupled–type PIM (TC-PIM) parameters and the location of the gearbox are based on the speed range of the electric motor and the internal combustion engine. The parameters of the TC-PIM (i.e., k 1 and k 2) are based on the k ratio theory. Numerical simulations of an extra-urban driving cycle and acceleration tests reveal that a higher k ratio has greater improved power-assist ability under a pre-transmission architecture. For example, a k ratio of 1.6 can improve the power-assist ability by 8.5% when compared with a k ratio of 1. By using an appropriate gear ratio and k ratio, the top speed of a hybrid electric vehicle is enhanced by 9.3%.

Zia, Furqan. (2017). This report presents a detailed description of the design, simulation, modelling and implementation of practically designed and manufactured low- budget Parallel Hybrid Car. The novel design of this car helps in reducing fuel consumption with better performance and efficiency than the conventional hybrid vehicles. The idea of this project was proposed and implemented by the engineering students of DHA Suffa University, Pakistan. The motive behind this project is to cope with the modern world technology and demonstrate this concept in which the low-cost car is fuel-efficient and environment-friendly, capable of generating electricity for itself and preserving the environment from deadly carbon-monoxide to overcome the hazards of global warming. This project proposes a novel design of a hybrid car where the car is capable of propelling by an electric motor or internal combustion engine. The novel concept for combining the benefits of both these sources, which is more efficient in performance than the conventional vehicles is also provided in this detailed report.

Kumar, C. & Subramanian, Shankar. (2015). Hybrid Electric Vehicles (HEVs) are emerging as alternatives to the traditional Internal Combustion Engine (ICE) driven vehicles to meet stringent emission norms, environmental and energy concerns. A commonly seen HEV configuration is the Parallel Hybrid Electric Vehicle (PHEV), in which both the ICE and electric motor are mechanically coupled to drive the wheels. Depending on the level of hybridization, which is defined as the ratio of motor power to the total power of the drive train, the PHEV is further classified into Mild, Full, and Plug-in hybrid. Regenerative braking is a key feature in HEVs that improves the fuel economy. The amount of energy regenerated depends on the motor, battery specifications and the control strategy. The design and analysis of the drive system and the control strategy for a typical Indian vehicle is the key focus of this paper. This involves the determination of engine power, motor power, gear ratios of transmission and battery specification to meet the drive requirements such as acceleration, maximum speed and gradeability. Also, the control strategies for both traction and braking have been discussed in this paper. Further, by considering the Modified Indian Drive Cycle and a real time speed plot, numerical simulation has been performed to evaluate the benefits in terms of fuel economy, compared to the conventional ICE driven vehicle. The simulation results shows that, in a full hybrid configuration with regenerative braking, the vehicle fuel economy can be improved by up to 32% in Indian driving conditions compared to the conventional ICE drive. The fuel economy can be improved further in hybrid powertrain with the engine turned off while braking instead of operating at idle speed.

3. METHODOLOGY

3.1 RESEARCH METHODOLOGY

The layout of the drivetrain system will used to classify hybrid electric vehicles. Series, hybrid, parallel hybrid, and series-parallel hybrid will among the classifications. When designing a hybrid electric vehicle, the propulsion engine, electric traction motor, generator, and energy storage devices must all be rated based on the desired vehicle performance. It must be checked that the vehicle performance standards are efficient after the design will be completed.

The determination of the driving cycle, as well as its analysis for fuel efficiency and emissions, will be the first approach used once the hybrid electric vehicle will designed. Currently, Europe, North America, and Japan provide the majority of the drive cycles. China is also working on its own drive cycles, which are based on its own road infrastructure. The first stage in creating a driving cycle will to monitor and record real driving behaviours, which will be driving behaviours that occur in real time and match to the vehicle being developed. The collected data will must be processed in order to create a realistic cycle based on actual driving conditions. The information gathered will divided into groups based on traffic circumstances.

4. RESULTS

4.1 HYBRID ELECTRIC VEHICLE DESIGN AND ANALYSIS

Two-wheeled vehicles are often used for transportation in India. A hybrid electric vehicle prototype is being built to provide these improvements to these two-wheeled vehicles. Today, every motorcycle and moped uses a gasoline-powered internal combustion engine. However, the number of electric motor-powered bicycles that get their juice from batteries is still rather low. A hybrid electric car combines the best of both worlds. Great speeds, high torque, reliable maintenance, and reliable replacement parts are all within the reach of ICE-powered two-wheelers. Vehicles powered by electric motors have lower top speeds and torque capacities but require less maintenance and fewer parts. When compared to electric motors, ICE systems have a longer lifespan. As charging times increase, electric-motor driven cars will be less usable in times of urgency. Although internal combustion engines (ICE) are more efficient than electric motors, their use is limited since the cost of gasoline is so prohibitive for the average person. The batteries used in EVs have a certain number of charges and discharges before they need to be replaced. The buyer is likely to think twice about purchasing an electric car because the cost of the battery will account for around 25 percent to 35 percent of the total vehicle price. The research done on electric scooters supports all these claims, as is evident from the goals we set out to accomplish with our hybrid design.

4.2 DRIVETRAIN CONFIGURATIN AND DESIGN

To illustrate the construction of the drivetrain in parallel hybrid or torque coupled hybrid electric cars, Figure 4.1 is provided. The primary components of this powertrain setup are the engine controller, motor controller, and electric motor. The accelerator will be used in conjunction with a sophisticated controller to regulate the vehicle's engine output and motor speed. The signals utilised for communication between the vehicle's components and the controller are processed by a drivetrain algorithm specifically developed to synchronise the components with each other. Component controllers are used by some parts to handle signals from the vehicle controller. Torque coupling must be regulated in this set-up by manipulating the ICE and electric motor that serve as propulsion sources.

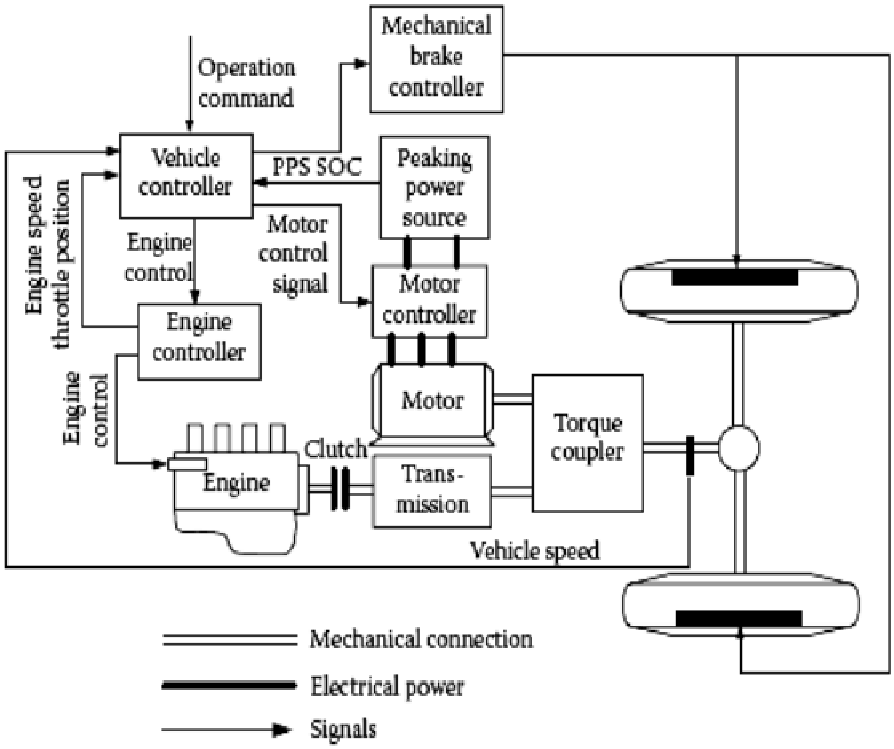

Figure 4.1: Drive train structure of the parallel (torque coupling) hybrid vehicle

Important considerations in this drivetrain configuration include

- Engine power
- Electric traction motor
- Energy sources
- Control strategy of the drive train

Keeping these considerations in mind, we are developing a parallel drive train.

- meeting all requirements for slope, acceleration, and top speed
- Superior efficiency hybrid electric car

4.3 PARAMETRIC DESIGN OF DRIVETRAIN

4.3.1 ENGINE POWER

Drive train characteristics in parallel hybrid electric cars include the internal combustion engine, electric motor, energy capacity, and gear ratios, and are determined by the control method and sources. These settings must be decided upon according to the vehicle's performance and requirements.

Expressions 4.1 and 4.2 calculate the tractive power necessary to overcome the road load or road resistance under the conditions of a level road and a constant speed.

Fr is the coefficient of rolling resistance; M is the vehicle's mass; Pe is the engine's power; V is the vehicle's speed; an is the air density; Af is the vehicle's frontal area; CD is the aerodynamic drag coefficient; g is the gravity due to acceleration; and I is the road's gradient in percentage.

$$P_e = \frac{V}{1000\eta_{t,e}} \left(f_r Mg + \frac{1}{2}\rho_a C_D A_f V^2 + Mgi \right) \text{ KW} \qquad (4.1)$$

$$P_e = \frac{V}{1000\eta_{t,e}} \left(f_r Mg + F_w + F_g \right) \text{ KW} \qquad (4.2)$$

Where is the mass factor coefficient, the total engine tractive power of the vehicle is calculated as the sum of the tractive power needed for acceleration and the tractive power needed to overcome the resistances.

$$P_e = \frac{V}{1000\eta_{t,e}} \left(f_r Mg + \frac{1}{2}\rho_a C_D A_f V^2 + Mgi + M\delta \frac{dV}{dt} \right) \text{KW} \qquad (4.3)$$

The term 4.4 describes the power transfer from the engine to the driving wheels as a torque.

$$T_w = i_g i_0 \eta_t T_P \qquad (4.4)$$

Where TP is the torque output in terms of power flow, ig is the gear ratio in terms of the input rotational speed, i0 is the gear ratio in terms of the final drive, and t is the efficiency in terms of the power driveline.

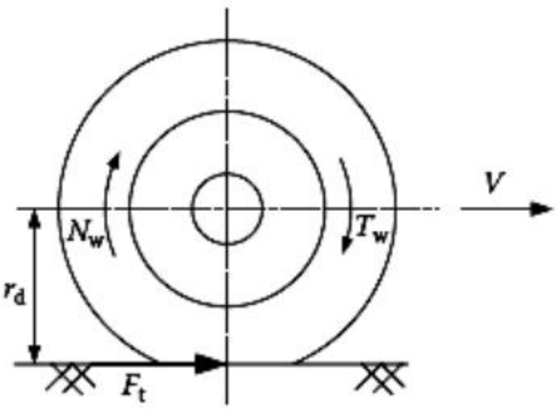

Figure 4.2: Tractive effort on the driven wheels

Figure 4.2 shows the expression for the tractive effort on the driven wheels.

$$F_t = \frac{i_g i_0 \eta_t T_P}{r_d} \quad (4.5)$$

The rotating speed (RPM) of the driven vehicle is given by expressions 4.6 and 4.7.

$$N_w = \frac{N_P}{i_g i_0} \quad (4.6)$$

$$V = \frac{\pi N_m r_d}{30 i_g i_0}\ m/s \quad (4.7)$$

For cars with manual transmissions, NP is the engine speed, whereas for those with automatic transmissions, NP is the turbine speed in relation to the torque converter.

In order to go forward, the vehicle's engine has to put off a certain amount of torque. The average power provided by the engine should be higher than the average load demanded during the stop-and-go situations.

4.3.2 Electric Motor Power Drive Design

The factors acceleration, power demand, and performance all play a significant impact in vehicle propulsion based on the selected motor. In parallel hybrid cars, the motor serves as a supplemental propulsion unit only when the demand is highest.

Figure 4.3 depicts the features of variable speed electric motors. The motor will maintain a consistent torque in the low-speed range, and a constant power in the high-speed range. To express this quality, we use the speed ratio x, which is the top speed divided by the lowest speed. Geared propulsion vehicles powered by an electric motor can take use of this aspect in their design.

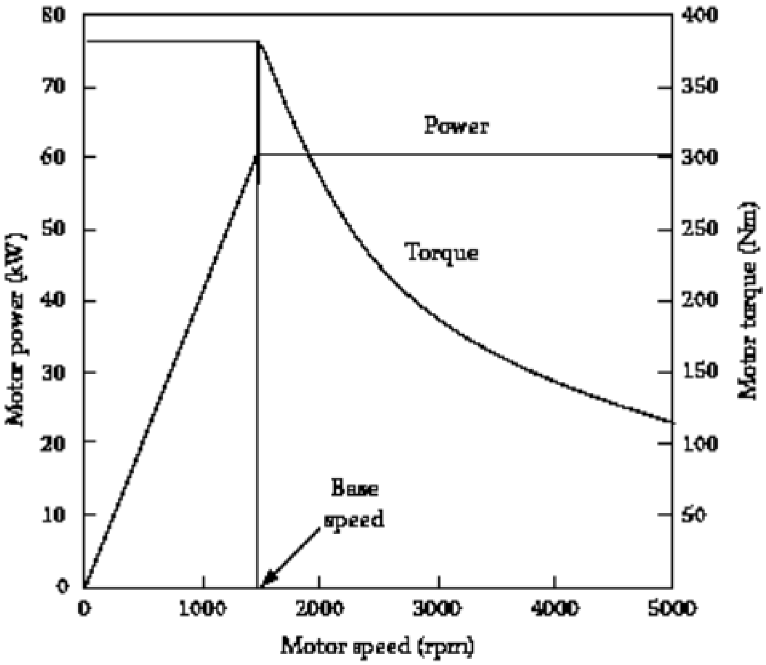

Figure 4.3: Characteristics of variable speed electric motor

Vehicle performance is measured in terms of its gradeability, cruising time, and top speed.

Expressions 4.8 and 4.9 determine the vehicle speed and the tractive effort generated by a traction motor on driven wheels, respectively.

$$F_t = \frac{T_m i_g i_0 \eta_t}{r_d} \quad (3.8)$$

$$V = \frac{\pi N_m r_d}{30 i_g i_0} \quad (3.9)$$

Where Tm and Nm are the motor's corresponding torque in Newton-meters and speed in revolutions per minute, respectively; ig is the transmission's gear ratio; i0 is the final drive's gear ratio; t is the efficiency of the entire driveline from the motor to the driven wheels; and rd is the driven wheels' radii.

5. DISCUSSIONS

It's no secret that urbanisation has had far-reaching consequences for society at large. As things are, automobiles are indispensable to modern life. This means that the number of cars on the road in urban areas is always growing. Nonrenewable sources of energy, such as gasoline and diesel, power the vast majority of these vehicles. These fires are dying down gradually, so their lifespan is uncertain. When there is a shortage of oil and a government that can't control it, it can lead to civil war. These elements contribute to ever-increasing oil costs, which are having a devastating effect on the standard of living of the average person.

Two-wheeled vehicles are often used for transportation in India. A Hybrid Electric Vehicle prototype is now under development to provide these improvements to these two-wheeled vehicles. At the moment, the only type of engine available for motorcycles is the internal combustion engine (ICE), and all of these use gasoline as their power source. However, the number of electric motor-powered bicycles that get their juice from batteries is still rather low. Hybrid electric vehicles are the result of combining the two types of power sources. Generally speaking, ICE-powered two-wheelers may achieve fast speed and high torque with reliable qualities in maintenance and replacements. Vehicles powered by electric motors have lower top speeds and torque capacities but require less maintenance and fewer parts. When compared to electric motors, ICEs have a longer lifespan. As charging times increase, electric-motor driven cars will be less usable in times of urgency. Despite being more effective than electric motors, ICEs are rarely used by the general public because to high gasoline prices. The batteries used in EVs have a certain number of charges and discharges before they need to be replaced. The buyer is likely to think twice about purchasing an electric car because the cost of the battery will account for around 25 percent to 35 percent of the total vehicle price.

6. CONCLUSION

The designer of an electrical system needs to be aware of power consumption and how to control it. The power source's battery will eventually run down and require recharging after being used for a while. The car's powertrain and any in-vehicle electrical systems or appliances are powered by the battery, thus keeping it charged is essential. Therefore, it is important to have up-to-the-moment data on the battery's health in terms of distance. The battery is crucial to the operation of electric and hybrid electric cars. Any high-end automobile has several electrical subsystems and components, each of which has its own unique power needs. The range, acceleration, and functionality of an EV are all determined by its battery. The success of any vehicle designed to conserve gasoline requires knowing its power consumption, efficiency, average, pickup, charging time, discharge time, and maximum range. The research may have positive consequences for the automobile industry as a whole, and for the field of electric vehicles in particular. The next portion of this chapter provides a summary of the research conducted and is organised according to its main components. This section provides a synopsis of the research done to date and a roadmap for where the field is headed next.

REFERENCES

1. Maddumage, Waruna&Abeyasinghe, Kasun &Perera, Malika &Attalage, Rahula. (2019). Design approaches for automotive hybrid-electric powertrains: A review.
2. Bai, Fan & Pai, Ping-Hao & Yang, Cheng Jung & Huang, Kuohsiu. (2019). Development of Transmission Systems for Parallel Hybrid Electric Vehicles. Applied Sciences. 9. 1538. 10.3390/app9081538.
3. Zia, Furqan. (2017). Design and Fabrication of Parallel Hybrid Car. 10.13140/RG.2.2.20204.59527.
4. Kumar, C. & Subramanian, Shankar. (2015). Design and analysis of a parallel hybrid electric vehicle for Indian conditions. 1-12. 10.1109/ITEC-India.2015.7386878.
5. Ahmed Al-Samari 2017, 'Study Of Emissions And Fuel Economy For Parallel Hybrid Versus Conventional Vehicles On Real World And Standard Driving Cycles' , Alexandria Engineering Journal, vol. 56, pp. 721–726.
6. Long, VT &Nhan, NV 2012, 'Bees algorithm based optimization of component size and control strategy parameters for parallel hybrid electric vehicles', International Journal of Automotive Technology, vol. 13, pp. 1177-1183.
7. Cheddie, DF & Munroe, ND 2006, ‗Three dimensional modeling of high temperature PEM fuel cells', Journal of Power Sources, vol.160, no. 1, pp.215-223
8. Lobato, J, Cañizares, P, Rodrigo, MA, Pinar, FJ, Mena, E &Úbeda, D 2010, ‗Three-dimensional model of a 50 cm2 high temperature PEM fuel cell: Study of the flow channel geometry influence', International journal of hydrogen energy, vol. 35, no. 11, pp.5510-5520.
9. Khazaee, I &Ghazikhani, M 2013, ‗Three-Dimensional Modeling and Development of the New Geometry PEM Fuel Cell', Arabian Journal for Science and Engineering, vol.38, no. 6, pp.1551-1564.
10. Saengrung, A, Abtahi, A &Zilouchian, A 2007, ‗Neural network model for a commercial PEM fuel cell system', Journal of Power Sources, vol.172, no. 2, pp.749-759.