Development of hybrid electric vehicle with DC-DC converters using hybrid energy source

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***Abstract*— The hybrid electric vehicle plays an important role in the automobile industry. The development of hybrid electric vehicles helps in the reduction of greenhouse gases and need not to depend on fossil fuels. The hybrid electric vehicle integrates with both the internal combustion engine and the electric motor. This helps to improve the sustainability of the system. This is enhanced through DC-DC converters. They help to transfer seamless transfer of energy through various sources and loads to the vehicle's electrical system. The overall performance of the system is achieved through efficiently converting and regulating the voltage levels. This also helps to improve the energy utilization of the electric vehicles. The smooth energy flow is achieved through the development of various control strategies. The various challenges in the functioning of hybrid electric vehicles are resolved through adopting deep learning techniques. Deep learning is artificial intelligence which functions based on the activities of human intelligence. The energy management is obtained through optimizing control parameters. The battery state of charge and energy exhaustion are detected and monitored through optimization techniques. The genetic algorithm is used for optimization of power management to obtain a more reliable and efficient system. This helps to provide automatic decision-making on how to distribute power from the hybrid energy sources. This is obtained as a sustainable transportation option due to its improved efficiency with reduced emissions.**

Keywords*— *Hybrid electric vehicle, Greenhouse gases, DC-DC converters. Deep learning, Genetic algorithm, Sustainable transportation option

I. INTRODUCTION

The hybrid electric vehicle is an innovative development to enhance power consumption. Various innovations were adopted early in the automobile industry to produce sophistication with producing environmentally friendly vehicles [1]. The important aspect of designing electric vehicles is to obtain the convenience and capabilities as similar to traditional vehicles. They are adopted with dual source with battery stack [2]. The dual power set up helps in the optimization of energy from the available sources. This helps in obtaining reliable and efficient functioning.

Various kinds of hybrid electric vehicles are classified based on their performance and structure. The internal combustion engine and the electric motor are mechanically connected to the wheels in the parallel form of hybrid electric vehicles [3]. The vehicle can have the potential to operate on the engine and the electric motor alternatively. Parallel hybrids are the familiar examples [4].

The internal combustion engine is used to generate electricity to charge the vehicle's batteries in the series form of hybrid electric vehicles. The electric motor is the only source of propulsion for the wheels for movement. They can run only on electricity for a limited distance before the engine paves the way for recharging the batteries [5]. The plug-in hybrids are much more relevant to the parallel hybrids. They have larger battery packs that can be recharged by plugging into an electrical source. The benefits of hybrid electric vehicles include enhanced fuel efficiency with improved system performance [6]. Artificial intelligence plays a significant role in the field of automobiles. The various innovations and automations are implemented through artificial intelligence evolving machine learning and deep learning techniques [7]. Deep learning can able to progress progressive control algorithms that are used for the optimization of the operation of the internal combustion engine in hybrid electric vehicles. The optimization algorithms help to achieve the most effective power distribution based on driving conditions and performance aspects [8]. Artificial intelligence can able to analyze data from various sensors and sources.

The battery state of charge can be monitored and analyzed properly through the aid of artificial intelligence techniques. They help to adjust the power distribution for the optimization of battery management. Another factor involves regenerative braking which includes two parameters such as

deacceleration and braking [9]. This helps in the identification and providing the balance between regenerative and friction braking. The vehicle's speed and distance are controlled through the adaptive cruise control parameters [10]-[14]. It helps in route planning to find the best optimum routes. Artificial intelligence can monitor vehicle performance and provide predictive maintenance alerts with notifications.

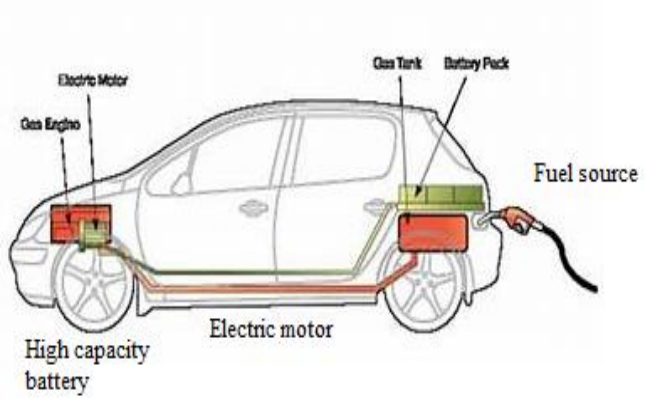

Fig 1: Hybrid electric vehicles

Figure 1 represents the hybrid electric vehicles. Thus deep learning with an optimization algorithm can able to provide higher efficiency for hybrid electric vehicles.

II. EXISTING SYSTEM

The existing system is implemented without the aid of machine learning which results in various drawbacks as shown in figure 2. The various drawbacks are listed below.

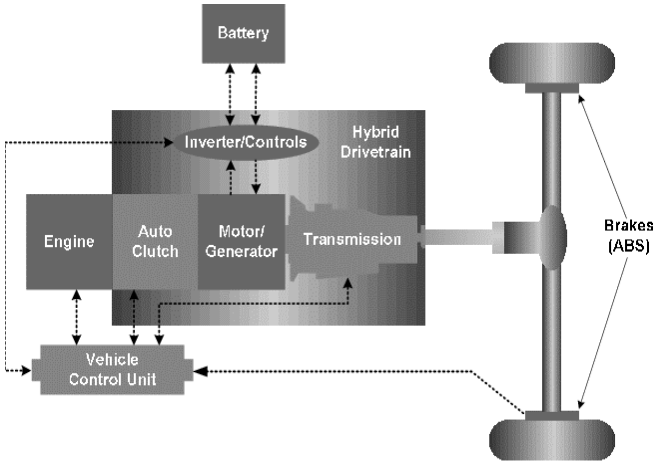

Fig 2: Existing system

- The machine learning algorithm required an amount of data to to trained. Collecting and managing the necessary data is a challenging task which needs prior work [15]-[18].

- The performance and functioning of electric vehicles are highly complex and require extensive knowledge to understand and functioning of the system [19].

- The machine learning model depends upon the quality of the data. These complex structures are highly difficult to analyse and interpret [20]-[22].

- The machine learning data can overfit the training data. This leads to poor generalization. They may lead to various vulnerable attacks and malicious activities in the network [23].

- The machine learning models lead to a lack of transparency in the system. This leads to higher difficulty in explaining the decisions and various behaviours in the system [24].

- This leads to various ethical questions regarding the rules and regulations as prescribed. Various issues such as accountability and decision-making may arise [25]-[29].

To overcome the various drawbacks of the existing system, the proposed system is implemented using deep learning techniques.

III. PROPOSED SYSTEM

The development of a hybrid electric vehicle (HEV) with DC-DC converters using a hybrid energy source involves combining two or more power sources to improve vehicle efficiency and reduce emissions.

Hybrid energy source:

The hybrid energy source involves two or more forms of energy sources. They are listed below.

Internal Combustion Engine (ICE): Fueled by gasoline or diesel.
Electric Motor(s): Powered by batteries or various electrical sources.
Battery Pack: Stores electrical energy for Future usage
Regenerative Braking: Captures kinetic energy during braking and converts it into electrical energy.
Auxiliary Power Unit (APU): A small engine or generator used to charge the battery

The DC-DC converters are an important part of the hybrid electric vehicles. This is important for converting the electrical power between the various sources and loads in the system. They are used for converting the voltage levels between the high-voltage battery pack and the lower-voltage electrical system. When the internal combustion engine starts to ignite, the automobile acts as a generator to produce output. The electrical energy is converted into an appropriate voltage level using DC-DC converters. The genetic algorithm is used to optimize the power consumption in hybrid electric vehicles.

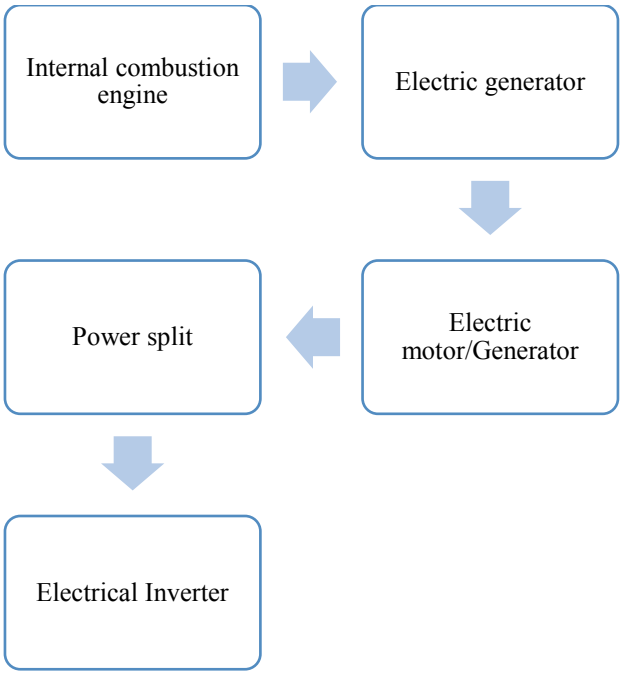

Fig 3: Stages in the proposed system

Figure 3 represents the various stages in the proposed system.

IV. Implementation of the Proposed System

The proposed system is implemented through various stages as listed below.

Stage 1: Research analysis

TABLE I: Trends and consumer preferences

Parameter	Description
Market Segment	Compact HEVs
Consumer Preferences	Fuel efficiency
Competitor Analysis	Honda Insight
Key Findings	Strong demand for compact HEVs

Table I shows the trends and consumer preferences.

Stage 2: Conceptual design

TABLE II: High level design of HVEs

Design Parameter	Value
Powertrain Configuration	Parallel Hybrid
Energy Source	Lithium-ion Battery + Regenerative Braking
DC-DC Converter	Buck-Boost Converter

Table II demonstrates the High level design of HVEs

Stage 3: Detailed design

TABLE III: Component and subsystems

Component	Specification	Supplier
Electric Motor	50 kW	Supplier A
Battery Pack	10 kWh	Supplier B
DC-DC Converter	Buck-Boost	Supplier A

Table III shows the components and subsystems

Stage 4: Prototype development

TABLE IV: Working prototype of EVs

Task	Progress	Issues
Fabrication	90%	Material delay
Powertrain Integration	80%	Material delay
Fabrication	70%	Issues in software integration

Table IV represents the working prototype of EVs

Stage 5: Testing and validation

TABLE V: Prototype testing

Test Type	Parameter	Result
Fuel Efficiency	60 mpg	>50 mpg
Emissions	30%	90 g/km
Power consumption	80%	High

Table V shows the Prototype testing.

Stage 6: Modelling and simulation

TABLE VI: Modeling

Task	Description
Vehicle Modeling	Mathematical model of the vehicle's performance
Energy Source Modeling	Energy source's output
Converter Simulations	DC-DC converter performance

Table VI demonstrates the modeling of electric vehicles.

Stage 7: Integration and testing

TABLE VII: Testing process

Task	Description
Component Integration	A vehicle with the chosen components
System Testing	Testing hybrid system's performance and efficiency
Safety Evaluation	Safety standards.

Table VII represents the testing process.

Stage 8: Cost analysis

TABLE VIII: Pricing strategies

Cost Component	Cost
Components	Rs 12000
Labor	Rs 5000
R and D	Rs 2000
Total Cost	Rs 19000

Table VIII shows the Pricing strategies.

Stage 9: Certification and compliance

TABLE IX: Regulations and standard

Task	Description
Regulatory Compliance	Safety and emissions standards.
Certification Tests	Regulatory approval
Documentation	Documentation for compliance purposes.

Table IX depicts the regulations and standards

Stage 10: Production and launch

TABLE 10: Final process in the execution of HEV

Task	Description
Production Setup	Production line for the hybrid vehicle.
Marketing and Sales	Launch the hybrid electric vehicle
Post-Launch Support	Provide customer support

Table 10 demonstrates the final process in the execution of HEV

V. SIMULATION RESULT

The performance analysis of the proposed system is evaluated through running in Matlab Simulink as demonstrated in Figure 4.

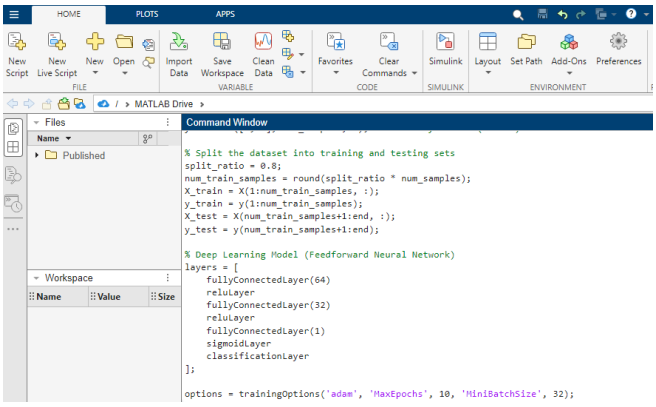

Fig 4: Matlab implementation

Results:
Total energy consumed: 44.91 kWh
Fuel cell energy contribution: 6.64 kWh
Battery energy contribution: 38.27 kWh

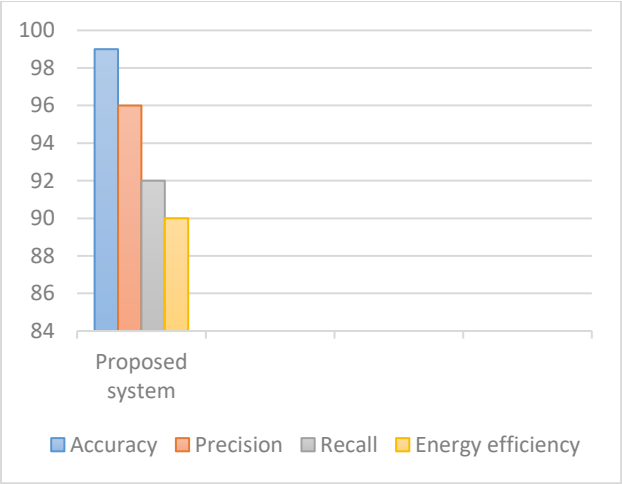

Fig 5: Performance metrics

Figure 5 demonstrates the performance metrics of using hybrid optimization techniques.

VI. Conclusion

The development of hybrid electric vehicles provides an important aspects in the field of the automobile industry with improved automation. The advanced technology integrates with the traditional internal combustion engines (ICE) with electric power sources such as batteries and regenerative braking systems. This helps in the reduction of fuel consumption and fuel emissions. This helps in obtaining a more sustainable and efficient mode of transportation. This can be able to switch between the power sources through optimizing improved performance and fuel efficiency. The transfer of energy is done through the DC-DC converters. This helps to monitor and analyze the vehicle operation at its peak efficiency. This helps to reduce fuel consumption and able to obtain reduced cost parameters. This helps to reduce the overall environmental impact. The integration of hybrid energy sources promotes the reduction in the emission of greenhouse gases. Thus the developed system provides much reliable and environmentally friendly system for transportation system.

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