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Research on Vehicle Dynamic Control (VDC) System for Designing Hybrid Electric Vehicles Using Renewable Energy Resources

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Abstract **- The study is focused on the concept of a vehicle dynamic control system for promoting hybrid electric vehicles. Along with that, the study is also focused on renewable energy resources and their usage in the making of hybrid electric vehicles. It can be identified that China is a country where the largest number of hybrid electric vehicles can be identified while Sweden is a country where the lowest number of hybrid electric vehicles can be found. Some websites, journals, and articles help to gain knowledge and data about the vehicle dynamic control system and hybrid electric vehicles which are discussed in this research article. Apart from that, a specific theory has been used to understand and describe the concept of the research topic appropriately.**

Keywords— Vehicle dynamic control, hybrid electric vehicles, renewable energy resources, environment

1. Introduction

1.1 Introduction

Vehicle dynamic control is a system that refers to the use of several sensors to monitor the inputs of the driver as well as the motion of the vehicle. Afternoon on entering these aspects the system can control the brake pressure as well as engine output which helps the driver to maintain control in the cars. The study is focused on the concept of the vehicle dynamic control system and its uses for designing hybrid electric vehicles by the uses of renewable energy resources. Renewable energy resources refer to the resources that provide energies from renewable aspects such as hydropower, wind, solar, water, and others. The concept of the vehicle dynamic control system and its importance for designing hybrid electric vehicles is discussed in the article. Apart from that, the concept of renewable energy resources and their importance for hybrid vehicles as well as for the environment is disclosed in the research article.

1.2 Rationale

The usage of hybrid electric vehicles in different countries is increasing day by day as the number of people with environmental concerns is also increasing. There are so many countries that produce and use hybrid electric vehicles by using renewable energy resources as well as a vehicle dynamic control system to protect the environment and complete their needs. It is identified that China is the country that used the largest number of hybrid electric vehicles, ***nearly 4710 thousand***, in the world and Sweden is the country that used the lowest number of hybrid electric vehicles (Neves *et al.* 2019). Apart from that, some other countries which promote the usage of hybrid electric vehicles are Europe, the United States, California, Norway, Germany, France, UK, Japan, Netherlands, and others.

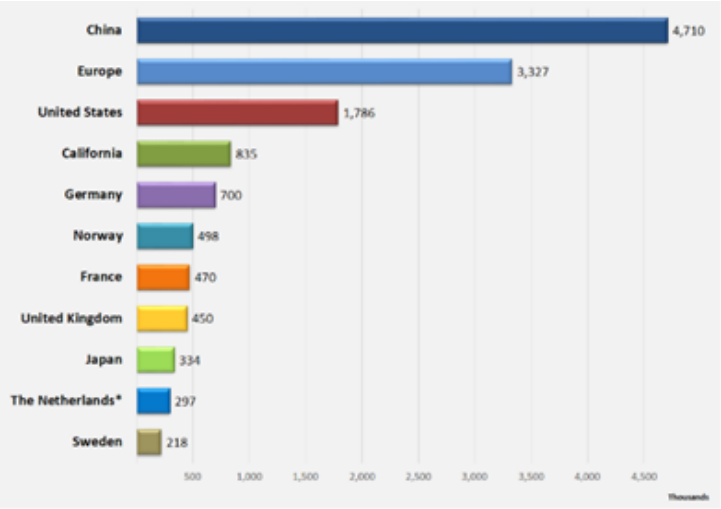

Figure 1: Countries that use hybrid electric vehicles

(Source: Neves *et al.* 2019)

1.3 Aim and objective

The aim of the research article is to explore the importance of the Vehicle Dynamic Control system for designing hybrid electric vehicles.

Objectives

- To describe the importance of Vehicle Dynamic Control system for the environment
- To understand the usage of renewable energy resources in the Vehicle Dynamic Control system
- To investigate the significance of hybrid electric vehicles for the environment

1.4 Research questions

Research questions of the research article are

- What is the Vehicle Dynamic Control system?
- What are renewable energy sources and how can they be used in the Vehicle Dynamic Control system?
- What is hybrid electric vehicles and how is it important for the environment?

2. Literature review

2.1 Concept of Vehicle Dynamic Control system

Vehicle dynamics control system is the process that leads to the development of vehicle industries. The entire process is focused on different sensors that are focused on the motion of the vehicle and the inputs of the driver. The ***dynamic control system*** is beneficial for the drivers as it helps to maintain the controls of the cars (Zhao *et al*. 2018). ***Nissan*** is one of the most popular car manufacturing companies which use the vehicle dynamic control system for producing their cars. The company uses different types of sensors in cars to enhance security and safety. The sensors are ***front-wheel speed sensors, VDC controller, steering angle sensor, rear-wheel speed sensor***, and others.

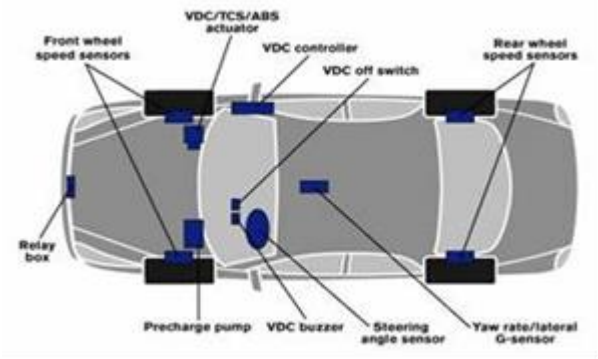

Figure 2: Vehicle Dynamic Control system

(Source: Zhao *et al*. 2018)

2.2 Idea about renewable energy resources

Renewable energy refers to the energies that are recyclable and come from some specific resources such as geothermal solar hydroelectric power water and others. The sources of renewable energies are mainly the sources of the environment. The use of these energies for completing the daily needs of people is not only beneficial for humans but also beneficial for animals and the environment (Wang *et al.* 2020). Vehicles are generally based on petrol and diesel which are decreasing day by day. In this situation, the use of renewable energies for using vehicles is the way to save petrol and protect the environment (). The use of renewable energy resources for designing hybrid electric vehicles is discussed below in the article.

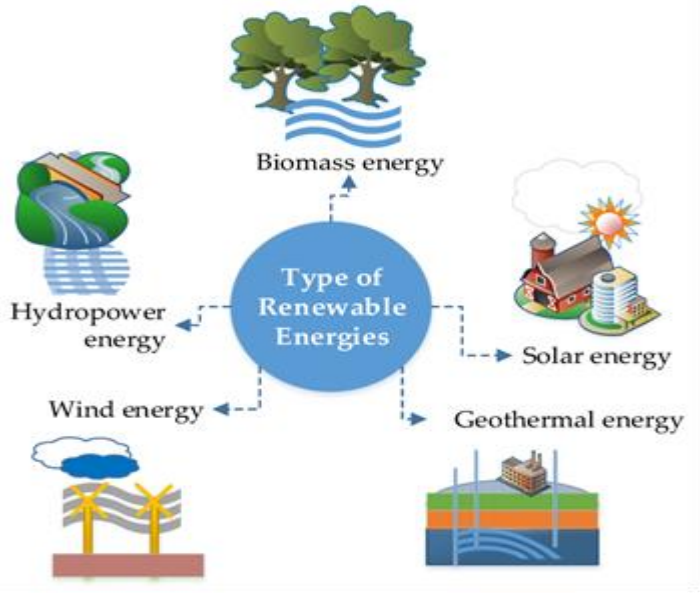

Figure 3: Renewable energy resources

(Source: Wang *et al.* 2020)

2.3 Hybrid electric vehicles

Hybrid electric vehicles refer to cars that rely on specific power resources such as petrol and electricity e for motion. Mostly the hybrid electric vehicles are relayed on electricity powers that come from renewable energy resources which helps to protect and save the other power resources such as petrol and diesel. There are mainly three types of hybrid electric vehicles such as ***fully hybrid, mild hybrids*** and the last one is ***plug-in hybrids*** (Qin *et al.* 2020). There are some advantages of hybrid electric cars such as these vehicles being environmentally friendly. Apart from that, it helps build effective financial conditions as it is less costly than petrol or diesel (Singh, 2019). Thus, the use of renewable energy resources and vehicle dynamic control systems for designing hybrid electric vehicles is discussed below in the research study.

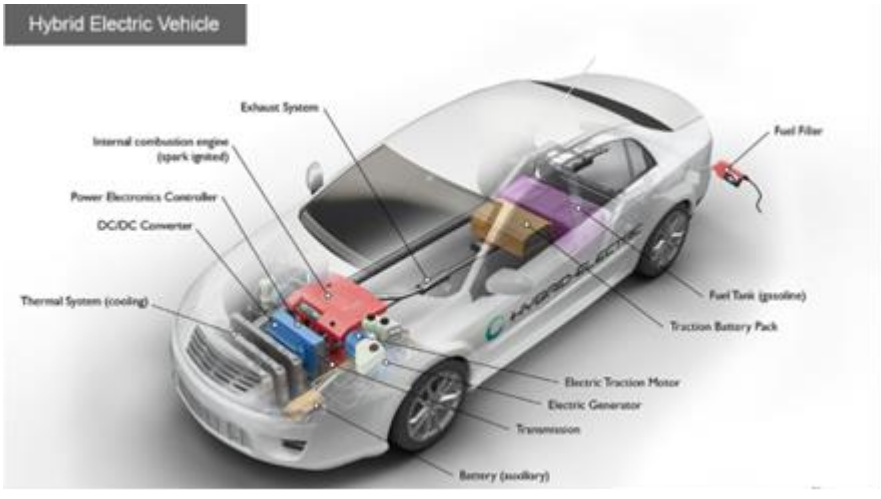

Figure 4: Hybrid electric vehicle

(Source: Qin *et al.* 2020)

2.5 Literature gap

Some literature based on the concept of vehicle dynamic control systems and hybrid electric vehicles is selected for review. Although the concept of the cycle main council system and renewable energy resources for hybrid electric vehicles is clear, the importance of hybrid electric vehicles for the environment is not clear which remains a gap in the literature review.

3. Methodology

Working mode	Power source	Power flow	Operation mode
Parking charging mode	AC power	Battery and super capacitor	Buck
Constant speed mode	Battery	DC	Boost
Acceleration mode	Super capacitor	DC motor	Boost
Braking mode	Braking energy	Battery and super capacitor	Buck
Super-capacitor charging mode	Battery	Super capacitors and DC motors	Boost or buck

Table 1: Different working modes of electric cars

(Source: Xia *et al.* 2018)

The different operation mode within hybrid electric cars has been identified in the above image where it can be assumed that braking mode within available working mode can be aligned with VDC (Xia *et al.* 2018). VDC is capable enough to control different types of brakes. Renewable energy resources in the form of solar hydroelectric power water and other renewable resources can be used to control brakes and reduce pollution. The power source can be assumed to be battery while power flow will be battery and super capacitor and operation mode will be boost. The methodology signifies that considering working mode, power source, power flow and others, it is possible to make use of renewable resources to develop electric cars.

4. Data analysis

Theme 1: Usage of Vehicle Dynamic Control system in car designing

Designing for any car using a Vehicle Dynamic Control system is important and the process is focused on vehicle motion. The driver's input is usually monitored along with vehicle motion where it has been found that electric vehicles have the ability to control brakes with the help of vehicle dynamic control. The engine output can be controlled through VDS. There are different companies such as Nissan that have been using VDS to control speed and have been applying brakes on wheels. The over steer and under steer are capable of applying brakes of the car through VDS (Nacpil *et al.* 2019). The strategies on energy management control are one of the requirements of charger stations are to design as well as control performance. A hybrid vehicle usually contains combustion engines along with an electric motor. The primary aim of an electric vehicle is to curb down the emission and pollution. Therefore, utilisation of respective VDS can be effective as an individual can reduce accidents through applying brakes of a vehicle.

In addition, parallel hybrid in association with gas engine and electric motor cause transmission in an electric vehicle. It has been seen that electric power along with gas engines offer propulsion power to an electric car. The designing of an electric vehicle through VDS involves three layers where the first layer is associated with calculation of lateral velocity as well as yawn rates. The yawn rate provides a yawn moment, and on the other hand, lateral force has been formed through the usage of methods of optimal control (Pondit *et al.* 2020). The dynamic behaviour of electric cars can be formed through the first layer revolving around the controller of the yawn moment. The second layer identifies the optimization of tire force that revolves around the distribution method of tire force through which tires of electric vehicles will obtain lateral force. Conversely, the yawn moment will need responses from the electric vehicle followed by meeting commands of the driver. The main aim of VDS is to enhance vehicle stability as well as enhance vehicle improvements (Piotrowski-Daspit *et al.* 2020). The workload of tire can be evaluated through ratio of resultant force of tire in square and vertical load of tire in square while cost can be defined as follow:

$$J_1 = \sum_{i=1}^{4} c_i \frac{F_{xi}^2 + F_{yi}^2}{F_{zi}^2}, i=1..4$$

The above cost function can be illustrated through making assumptions where J1 is the workload of tires, C1 is assumed as a weighting factor in respect of relative equations while Fx1-4, Fy1-4 is about satisfying different constraints.

Theme 2: Importance of hybrid electric vehicles for the environment

Hybrid electric vehicles are important for the environment. The biggest advantage of hybrid electric vehicles is that they have better mileage and the vehicles run cleaner. Hybrid electrics cars have an electric generator, electric training motor, battery pack, combustion engine that helps to generate the power of the hybrid electric vehicles. Hybrid electric vehicles have many advantages that also benefit the environment. The importance's are below here:

Less harmful emission of gas: The hybrid electric vehicles like hybrid cars have low carbon emission that helps to protect the environment. The big concern is Global warming that is fumes emitted from vehicles (Tucki *et al.* 2019). The harmful carbon-di-oxide or carbon monoxide damages the air and affects the environment. Hybrid electric cars when entered in the market, since then the hybrid electric cars use electric motors and for this reason hybrid electric cars burn less fuel. Using hybrid electric vehicles causes a low rate of emission.

Better mileage of gas: Hybrid electric vehicles have better gas mileage where other vehicles do not have this facility. It also reduced the level of fuel consumption that is useful for the environment. The vehicle saves more gases and provides the extra power that also helps the environment (Brough and Jouhara, 2020). Instead of gas engines, hybrid electric vehicles use electric motors to save the fuel that also helps the environment.

Pollutant's reduction: In the environment electric vehicles do not grow the pollution level due to low carbon emission level. Electric cars do not release the toxins where other cars release toxins like carbon-di-oxide that are harmful for the environment (Siddiqui and Dincer, 2019).

5. Conclusion and recommendations

5.1 Conclusion

In the above article, vehicle dynamic control system refers to the aspects of monitoring the vehicle. The importance of hybrid electric vehicles for the environment is necessary. The article shows the usage of the energy resources for the vehicle dynamic control system. Hybrid electric cars are designed for the use of vehicle dynamic control systems that have many issues like control brake pressure, the driver maintains the output controls that helps to reduce road accidents. The engine of the vehicles is controlled through the vehicle dynamic system that controls the pollution and produces the low rates of emission.

5.2 Recommendations

In the above research, electric hybrid vehicles improve the feathers like charging the battery, running the engine smoothly, accessory use of the limits and also load lightly all the time. The electric hybrid vehicles always produce a low carbon emission rate that is friendly for the environment. Hybrid electric vehicles help the environment by reducing pollution and saving fuel. Every company will produce hybrid electric vehicles to reduce pollution that will help the environment. The electric vehicle producing company recommended for the low price of the product, time of recharging the battery and also low cost of operating vehicle that helps to increase the business of hybrid electric vehicle company.

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