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Improving Energy Efficiency in Hybrid Electrical Vehicles using a Novel Mechanical Design

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Abstract: As a result of the problem of global warming, which is foundation for greenhouse effect, public are increasingly opting to replace traditional combustion vehicles with electric automobiles. This is why public are encouraged to develop an advanced electric vehicle. Developed countries conducted numerous studies of electric vehicles, usually over four seasons a year. This is due to the fact that electric or hybrid vehicles are becoming increasingly popular due to their environmentally friendly approach, low or almost nonexistent fuel consumption, low or nearly nonexistent taxes, and/or government purchasing incentives. Extremely congested metropolitan areas, on the other hand, can have a negative impact on the performance, reliability, and battery health of electric and hybrid vehicles due to excessive wear, long periods of waiting, and slow movement. For hybrid and electric vehicles, it may be necessary to monitor the parameters on a regular basis in order to prevent electrical or electronic malfunctions, because these types of problems can be extremely expensive to repair. Hybrid vehicles are one of the most effective means of increasing fuel efficiency while simultaneously lowering CO2 emissions from automobiles. Energy efficiency is the most significant concern in electric vehicles. In this paper we will design a HEV and its specifications also will be provided along with Experimental work flow. We will compare the results with Normal vehicles in term of average speed and proves that Our proposed HEV Performs well when compared to Normal Vehicles. Finally, this work proposes mainly an efficient model for energy consumption to improve battery life.

Keywords: Hybrid electric vehicle, Electric vehicle**,** Battery Life, Power Consumption, Energy;

1 Introduction

An electric vehicle is a zero-emission vehicle that is also environmentally friendly. Electric vehicles, on the other hand, remain unpopular with customers due to their lack of performance & failure to travel long expanse exclusive of recharging. As a result, consumers as well as environmentalists look forward to vehicles which combine the performance characteristics of traditional cars with electric vehicles' zero emission characteristics. In contrast, extremely congested metropolitan areas can have a negative impact on the performance, dependability, and battery health of electric and hybrid vehicles due to the excessive wear, long periods of waiting, and slow movement that occurs in these areas. Due to the high cost of repairing electrical and electronic malfunctions in hybrid and electric vehicles, it may be necessary to monitor certain parameters on a regular basis in order to prevent them occurring. There are many examples ranging from the efficiency of a torque converter to the improvement of shifting fluidity and responsiveness towards the much functionality, which add a car mass.

Power will be reused once again into the battery for capacity in Hybrid electric vehicles (HEVs), as occurs during regenerative breaking, for instance (which is generally squandered as warmth in an ordinary vehicle). Primary automakers like Toyota and Honda have effectively begun mass-creating Hybrid electric vehicles (HEVs), such as the Prius and Insight, which are quickly gaining popularity among consumers due to their excellent mileage and low emissions. In addition, a number of automobile manufacturers, including Mitsubishi, Nissan, Fiat, Renault, Ford, General Motors, and Subaru[1] sell hybrid automobiles. The quantity of optional electric vehicles is not extensively high when effectiveness is measured in terms of the amount of energy converted from crude oil to grip attempt at the wheels, but when the number of alternative electric vehicles is considered, it creates a significant distinction.

This paper [2] examines electrical parts and the general plan of a vehicle transformation to a Hybrid vehicle. It has been chosen to utilize an electric stockpiling unit for the battery (lead-corrosive) and the super-capacitors. It was feasible to move power in the two ways between the wheels, batteries, and super-capacitors due to the battery and super-capacitor that were utilized. Likewise, an EMC (Energy Management Computer) is introduced in the vehicle to screen the whole framework and figure out what every individual unit ought to do. Condenser banks, instead of batteries alone, altogether diminished the measure of force and energy needed for cycling and, subsequently, expanded battery life. The productivity is decreased, notwithstanding, in light of the fact that EMC is fundamentally used to move power among batteries and super-capacitors. To decide the essential force on the battery and condenser motors, the EMC speaks with the condenser and battery controls, the IC motor, and the driver. The data structure created measures cell voltages and flows, DC voltage, power, speed, stage current, and temperature. At the point when estimated boundaries surpass 9.5% of the cutoff level, an equipment based framework closure in the battery and condenser units is started for self-assurance.[3] Conducts extensive research into how battery managing will be utilized to extend the life of battery packs. The main element in this method is to examine & charge the batteries independently. HEV batteries require intelligent systems to maintain and extend battery life cycles due to their highly dynamic discharge and charging cycles. Because of assembling irregularities and operational varieties, every battery cell can have distinctive execution attributes. The author proposes that the monitoring be disabled and that charging cycles be more strictly regulated. They also discussed the various methods for charging the batteries, including constant charge voltage and current.

A solo charger is in use to charge the whole battery in the majority of HEV applications. The intelligent system under discussion includes individual chargers for each battery. AC/DC converters, which were utilized as battery chargers, have been significantly condensed in volume & load as a result of a number of technological advancements, making this possible. Each charger will be switched on automatically, & the energy limit can be adjusted slightly. More research attention is required, however, in order to improve the performance of HEVs while simultaneously reducing the emission of carbon dioxide gasses, which have a negative impact on the environment and must be addressed as a matter of urgency.

1.1 ALTERNATIVE FUELS:

In order to mitigate the negative effects of conventional vehicle emissions, alternative fuels are being used more and more frequently. Alternative fuels, particularly those derived from renewable resources such as ethanol and methanol derived from yields, as well as cellulose & organic-red biomass, are being considered. Unlike gasoline and diesel, alternative fuels such as natural gas, methanol, and gasoline are derived from fossil fuels, but they emit fewer pollutants than petrol & diesel.

A. Ethanol

Ethanol is made by fermenting sugar, which can be obtained from plants or cellulose. Without any technical modifications, all gasoline motorized customer cars will be filled with 10-15 percent ethanol. For diesel engines, this is also feasible after slight changes. The main uses of ethanol were that it reduces harmful gas emissions, such as CO2, Nitrogen dioxide etc.

B. Methanol

Methanol is most commonly made from fossil fuels (natural gas), but it can also be made from biomass. The use of methanol reduces emissions as well.

C. Biogas

Biomass is made from natural and cultivated biomass yields. It is considered today to be the most damaging biofuel to the atmosphere. The gas includes methane gas, carbon dioxide and water. In vehicle engines methane gas will be utilized as fuel.

D. Natural Gas

Natural gas is the main contaminant of fossil fuels with main methane. Natural gas emits 15-20% less carbon dioxide than gasoline, according to the EPA. Natural gas engines emit a low amount of particulate matter & hydrocarbons.

E. Gasol

Gasoline is, in essence, a fossil fuel. In comparison to petrol and diesel, the gas is moderately inexpensive & produces little drain emissions.

F. Hydrogen Gas (Fuel Cell)

An electrochemical power translation mechanism is a fuel cell. It uses hydrogen fuel & air oxygen to create electricity, water & heat. The only water emission is hydrogen[4]. Hydrogen & oxygen are undergoing moderately cool electrochemical response in an automotive fuel cell that produces direct electricity. This electrical energy is transferred to the motor of the vehicle, which drives the wheels. It is necessary to produce hydrogen in order to use this type of fuel because it is not naturally occurring and must be manufactured. It also needs to be saved. If hydrogen leaks and comes into contact with air, there's a chance of an explosion. Despite this, hydrogen gas, which is worn in fuel cells, is measured to be the most efficient source of energy for the future [5].

G. Batteries:

Batteries are portable electrical sources converted to mechanical energy for propulsion in the electric motor. For hybrid electric vehicle applications, a variety of battery types are available. The fixings are Lead Acid, Nickel Iron, Nickel Cadmium, Nickel Metal Hydride, Lithium Polymer, Lithium Iron, Sodium Sulfur, and Sodium Metal Chloride. Aluminum – Air and Zinc – Air are two sorts of precisely fuelled metal-air batteries [6] that are instances of this kind of battery. Battery execution rules: explicit energy, energy thickness, explicit energy, commonplace voltages, amp hour, power productivity, business accessibility, cost of activity, self-release rates, number of pattern of life and charging rates. The fashioner should likewise know how energy supply changes as far as encompassing temperature, charging and releases, battery structure, ideal temperature, energy strategies & freezing needs.

2. Literature Survey:

Hybrid automobiles were those which contain more than one source of driving power. common examples include hybrid vehicles powered by internal combustion engines, also known as hybrid electric vehicles (HEV). It is possible to receive HEV power from battery. In a hybrid vehicle, the battery container only be recharged while the vehicle is in motion It is during the charging process that the function of an electric motor is converted into that of a generator, which is to say (Figure 1). When a braking process[7] or deceleration occurs, the load on the vehicle increases as a result. Renewable braking is the term used to describe this loading process. one more category of HEV is plug-in hybrid vehicle (PHEV)[8]. [9] It is also possible to charge the PHEV battery from an external power source.

In general, there are three kinds of HEV. The HEV series is the first. Internal combustion engine (ICE) is solely utilized to spin the alternator in this case. The alternator is in charge of charging the battery. The electric motor is then powered by the battery. If the battery's capability is inadequate, ICE will charge it for you. There is no straight mechanical association among internal combustion engine & the vehicle's transmission.

The parallel HEV is the second type of HEV. This type of transmission box can be used with both internal combustion engines and electric motors. The electric motor begins to operate once the battery has been fully charged. When the battery is low, the car is driven by the internal combustion engine (ICE), while the electric motor is turned around. As a result of this alternation, the electric motor acts as a originator, supplying electricity to battery. The mechanism will guide the ICE & the electric motor to cooperate under certain conditions, such as when greater power or torque is required[10][11] (parallel). The battery must be charged to the required level in these circumstances. As a result, a parallel HEV with the same capacity is more powerful than a serial HEV.

A mix of serial and parallel HEV is the third kind. The transmission box and a generator are both linked to the ICE feature of this kind. To operate the motor, this producer is linked to converter. The transmission box is linked to motor.The 2017 Toyota Prius HEV was utilized in this research. This vehicle is series-parallel HEV with an ICE output system of 134 bhp/100 kW. The HEV electric motor produces 95 bhp.

The Prius is powered by 153 NiMH (Nickel-metal hybride) battery with voltage of 0.8 V per cell. The battery has a maximum voltage of 198.4 volts and a capacity of 6.5 amp-hours. As a result, the total energy capability is 1234.6 Wh (1.2 kWh)[12].

The electrical energy with a capability of 0.9 kWh will be transformed into a power of 78 kW minutes. It implies that if 78 kW of power is needed in one minute, the battery runs out in one minute and ICE replaces the electric motor completely. If the normal energy consumption of a vehicle in EV method is 13.4 kW, the battery can only power an motor for 4 minutes on a single charge. This assumes that the battery can be drained to 0 percent. In reality, the battery was never allowed to hit 0 percent and will never be allowed to do so. The battery will be refilled when it has 20-30% capacity remaining [13].

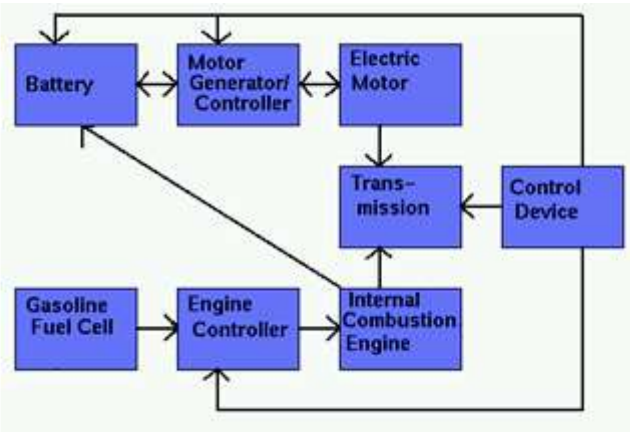

Figure 1. Operation of Hybrid Electrical Vehicle

Batteries are portable sources of electrical energy which is converted to mechanical energy in the electric motor for propulsion. There are many types of batteries in existence for hybrid electric vehicle application. They are Lead Acid, Nickel Iron, Nickel

Cadmium, Nickel Metal Hydride, Lithium Polymer, Lithium Iron, Sodium Sulphur and Sodium Metal Chloride. Examples of metal air battery which are mechanically refueled are: Aluminum – Air and Zinc – Air [14].

Battery Performance Criteria are Specific Energy, Energy Density, Specific Power, Typical Voltages, Amp Hour Efficiency, Energy Efficiency, Commercial Availability, Cost, Operating Temperature, Self – Discharge Rates, Number of Life Cycles and Recharge Rates. The designer also needs to know how energy availability varies with regard to ambient temperature, charge and discharge rates, battery geometry, optimum temperature, charging methods and cooling needs[15].

Combustion Engine involves basically the combination of two power sources, an internal combustion engine and an electrical machine [16]. The electrical machine is designed to handle transient power variations and helps the engine to operate more constantly such that higher efficiency and lower tailpipe emissions can be achieved [17].

There are many ways to create an electric – internal combustion hybrid. The variety of electric – ICE designs can be differentiated by how the electric and combustion portions of the power train connect, at what times each portion is operation and what percent of the power is provided by each hybrid component. Two major categories are series hybrids and parallel hybrids [18-19].

3. Design& Methodology:

A. Mechanical Design

This design of the planned HEV begins with functional block diagram, followed by the chassis design, the key apparatus concerned in the prototype, & the construction of the parts.

Functional block diagram: To handle the workflow of this research, an easy and complete block diagram is provided. The hybrid vehicle prototype was designed using the mechatronics design methodology shown in Figure 2.

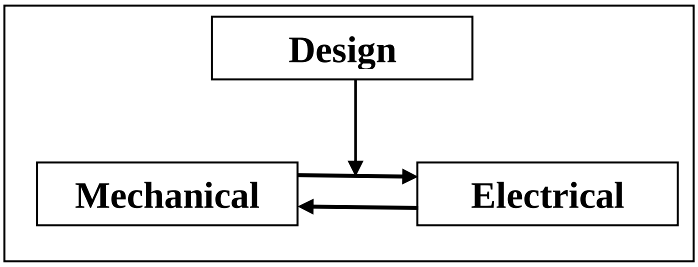

Figure 2.Block diagram of the proposed HEV

Chassis design: The mechanical design's foundation is the chassis. The chassis was designed to resemble just the back portion of the real vehicle, in order to account for the location where all of the major components would be housed and therefore minimize the prototype's production costs. After doing research, the dimensions are determined by taking into account the general size of the components. When it comes to the chassis's construction, angle aluminum is regarded to be the most important material. There are many reasons why this angle aluminum is ideal for the prototype's construction, including its low weight, ease of connection, and high strength.

Gasoline Engine: The engine used is the BG-328 brush cutter, which has a max output of 0.81kW. The fuel economy and weight of this engine are two of its most significant benefits. Table 1 contains a comprehensive specification of the product.

Table1: Product Specifications

Model	DG-526
Engine Type	4 Cycles, Double Cylinder, Fuel Engine
Dislocation	44.6 cc
Maximum Output	2.83 kW
Fuel	Combination of Fuel & gas with 4 cycles
Dimension (L X W X H)	456 x 352 X 521 mm
Dry Weight	10.6 Kg

DC motor: The kind of motor that is utilized may vary based on the vehicle's power system and its overall dimensions. Current internal combustion hybrid vehicles are more likely to utilize alternating current induction motors than commutated direct current motors, owing to both the power needs and the usually higher efficiency of alternating current induction motors. Even though, for minor, low pace vehicles, a DC motor of some kind would be preferable to reduce the general complexity of the vehicle design. By eliminating the need for a DC-to-AC converter, the use of DC engine can decrease the amount of power condition required on the grid. The fact that direct current motors are slightly less efficient than alternating current motors does not preclude their use in low-speed hybrid vehicles due to the lower cost and better balance of plant that can be achieved by using DC motors The package also includes mechanical components such as a sealed lead acid battery, alternator, and wheels, as well as transmission belting and chain.

In this research, experimentally performed. HEV is equipped with a data collection instrument that can capture fuel and energy consumption data within a specified period of time. In addition, statistics about the location of the car are also collected while driving. Vehicles are utilized in regular circumstances every day[13]. The research was carried out in the Jakarta, Bogor, Depok, Tangerang, Bekasi regions, in combination with crowded traffic conditions and roadways. Since the average temperature is very hot in the tropics, air conditioning is constantly utilized. Unlike PHEV, there is not a complete variety of BEV or ICE modes in HEV. So just one option is available, hybrid. HEV AC is powered by separate electric engine as opposed to AC on crankshaft rotating ICE cars.

The car is driven by the driver's behavior. Data are anticipated to be collected on the average distance each day. From this, fuel usage may be determined. The study findings will determine whether hybrid cars are sufficiently significant for fuel efficiency, which indirectly indicates a contribution to air pollution reduction levels

This work will concentrate on the usage of HEV fuel. For future research, data collected from the data logger will also be utilized.

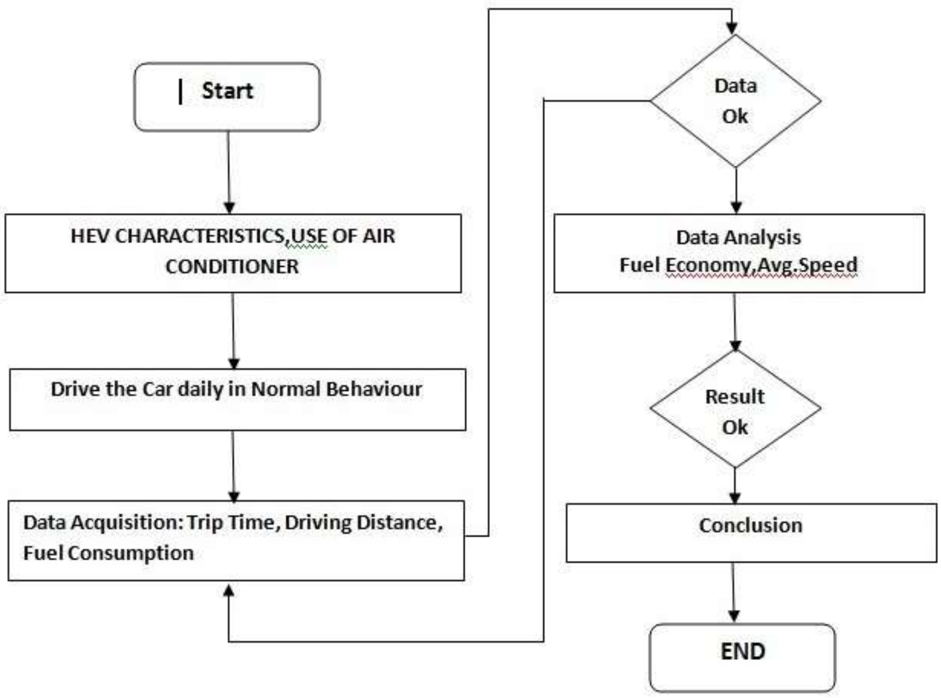

Figure 3. Experimental Work flow

4. Result Analysis:

In order to demonstrate the advantage of hybrid cars compared to conventional vehicles, the data gathered were aggregated at the average speed. Such parameter may be useful for characterizing the vehicle's moving environment. As a result, the vehicle is in a congested traffic environment with lower average speeds in urban environments, whereas in rural and highway environments, the vehicle's average speeds are increasing. Consumption curves were then constructed using average speed standards vary from 10 km/h to 120 km/h as starting points.

The average vehicle speed is depicted as the consumption of the Toyota Yaris Hybrid, Yaris Conventional, &Prius hybrid vehicles.

When compared to traditional technology, most of the hybrid technology's average speed values show a significant reduction in consumption: at low speeds (10 km/h), the speed is reduced by 53 percent. Specifically, three factors contribute to this efficiency: the thermal motor efficiency, the hybrid subsystems that allow the ZEV mode to be operated for a significant portion of the time, and the Hybrid Synergy Drive's regenerative braking capability.

Even though the Prius and Yaris Hy have similar trends in consumption versus average speeds, the Prius has lower consumption figures, which can be attributed in part to excellent effectiveness of energy improvement system, which is present in spite of the Prius's large mass. The Prius brake energy recovery system's high efficiency is because of the higher power of electric motor/

producer & the larger capability of the tractive batteries

It is not insignificant that the drivers' ability is not insignificant at such lower speed principles in which there are numerous accelerations & decelerations, and further negative effects may be achieved by driving conventional cars[20]. This is obviously absent in hybrid vehicles or it will be rounded out with the hybrid vehicle's power train. When driving at high speeds, such as those experienced while traveling down the highway, the function of the electric subsystem diminishes, and the fuel consumption of hybrid and conventional vehicles is nearly identical at high speeds, which is typical of highway driving.But in urban settings, the significant benefit of hybrid power trains and, combined with a lower consumption, "electric-like" behavior have a major advantage over most of the time as shown in Table2 & Figure 4.

Table2: Consumption Values Vs Average Speed

Average Speed	Yaris Conventional	Yaris Hybrid	Prius Hybrid
0	13	5.7	4.6
10	9.5	5.6	4.3
20	9.3	5.2	3.8
30	7.8	4.8	4.2
40	8.2	4	5.2
50	6.5	4.2	5
60	5.6	4.6	4
70	5.4	4.4	4
80	4.6	4.2	4
90	5.4	4.9	4
100	5.8	5.6	4.2
110	6.3	6.2	4.4
120	6.6	6.5	4.6

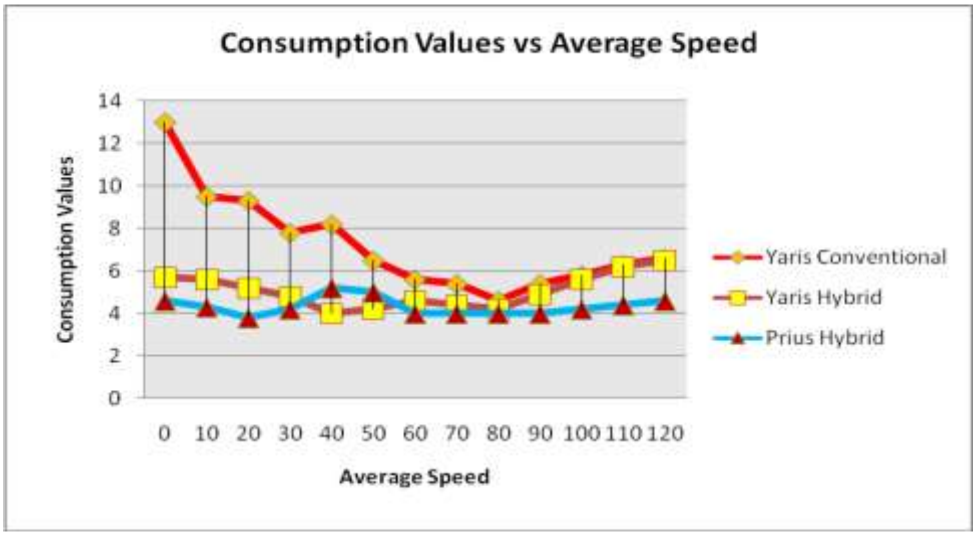

Figure. 4. Consumption values vs Average speed.

Table3: Percentage Vs Average Speed

Average Speed	YARIS-HY	PRIUS
11	70	79.56
22	65.36	75.6
30	58	71.3
42	46	69.6
52	42	62.8
61	39	59.6
72	37	52.3

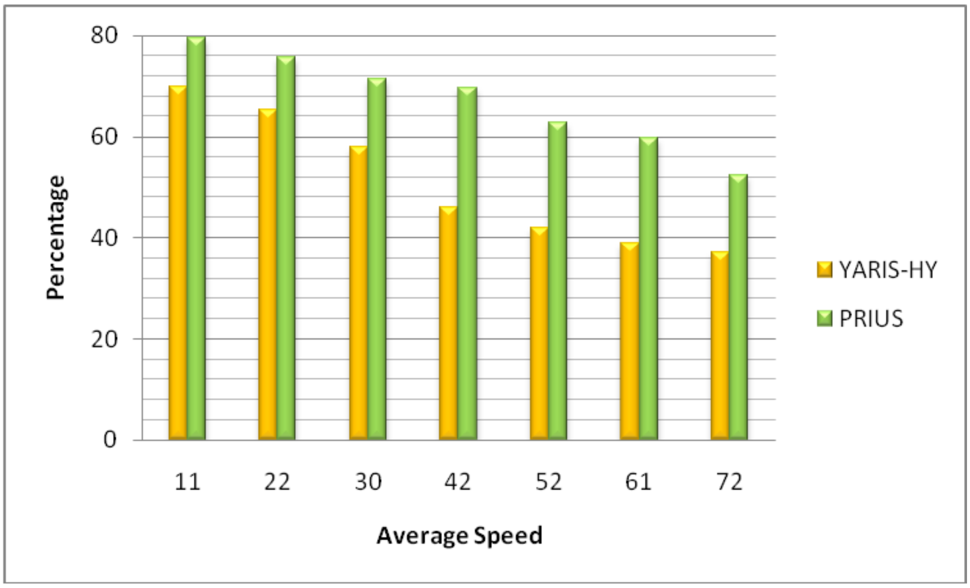

Figure 5. Percentage in ZEV mode for the average speed.

Figure 5 shows that when traffic is congested, the hybrid vehicle is operated on the ZEV mode for the majority of the time (69.5 percent Yaris and 79.56 percent Prius), with values of 30 km/h reduced to 58 percent for the Yaris and 71.3 percent for the Prius. According to a surprising finding, the Yaris' operation in ZEV mode is drastically reduced (by 19.8 percent), whereas the Prius' average speed is greater than 45.6% higher, thanks to the higher level of electrification in the higher-performance power train. This will also result in noteworthy reductions in local emissions, which are important contributors to air pollution in urban areas.

5. Conclusion:

The aim of this article was to analyze and classify electric and hybrid vehicle surveillance systems of this type. An HEV intelligently tackles the problems of the gasoline engine & the electric vehicle. It reduces emission assembly and the use of fuel. The problem of batteries for electric cars has been overcome. A HEV is loaded – it must never be connected. When power is not used, the engine can be used as a producer to transmit power from regenerative braking & from gasoline to batteries. The findings indicate that not only the kind of vehicle used, but also the driving method & pace used have a significant impact on consumption. The comparison between the two Yaris modes reveals that hybrid vehicles with lesser & average speeds (approximately 50% for 15 km/h) have lower fuel consumption than their non-hybrid counterparts. At increased speed and values of more than 85 km/h, both vehicles uses the equal utilization. On the one hand, the reduced hybrid vehicle utilization at low speeds is due to better effectiveness of hybrid motor compared to usual motor and other, the high performance of the motor off due to the utilization of the electric motor.

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