Design And Simulation Of Retrofitting Vehicles With Solar Powered System

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ABSTRACT

According to the current environmental conditions, the pollution percentage of pollutants exerted by the existing conventional vehicle is much higher than the estimated results. This paper presents a conceptual design of converting a conventional vehicle into a plug-in hybrid electric vehicle (PHEV) to reduce the pollution percentage in the conventional vehicle. The proposed propulsion system is configured as a parallel-hybrid concept. The vehicle will undergo with minimal changes. A model of variable drive systems provide a higher efficient drive axles in both front and rear wheels with respect to the source of energy used is defined. The front wheel could run with the IC combustion engine and the rear wheel with the in-wheel motor-hub, then providing the external control to the motor so that the speed of the motor can be controlled. A dual selection is provided at the choice of the user, to match their style of drive either in normal or electric drive modes. The model is built in the MATLAB /SIMULINK tool and its Performance analysis is done with the results obtained.

Index terms:

1. INTRODUCTION

In present, the situation of using up the world reserve of fossil fuel as well as the concern on environment is forcing the Automobile manufacturers to seek for alternative propulsion concepts to operate by other energy sources. As a result, the electric propulsion concept has come into interest. In electric vehicles, the consumed energy may come from different origins e.g. hydrogen(fuel cell), renewable energy (from grid) or even fossil fuel (generator driven by combustion engine). This reduces the consumption of fossil fuel. The further advantages of electric vehicles are high efficiency in energy conversion, the possibility of regenerative braking, low emission, low acoustic noise, control flexibility and renewable energy source.

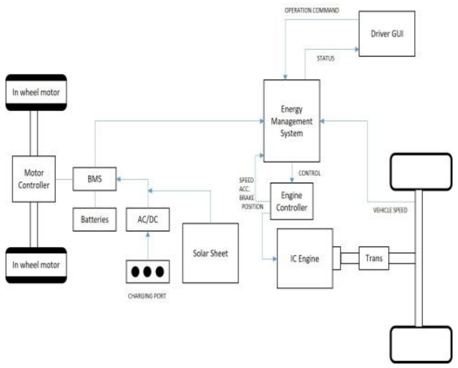


Fig: 1Architecture of propose vehicle model

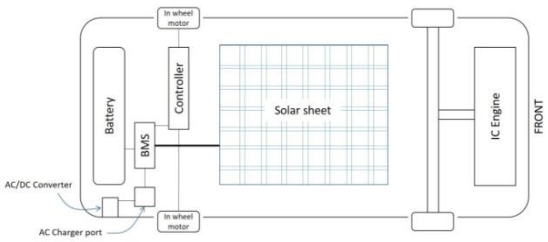


Figure : Architecture of proposed vehicle.

However, the implementation of electric vehicles still has many technical challenges to be solved. For example, the energy density of the energy storage, e.g. batteries, is not sufficient to run the vehicle with the comparable driving range in comparison to conventional vehicles. In order to overcome the limitation by the battery, the hybrid solution is proposed to combine the electric propulsion system with an additional on-board power supply for recharging the batteries. This power supply can be a fuel cell or a generator driven by a internal combustion engine. This vehicle type is called hybrid electric vehicle (HEV).

The reduction of gasoline consumption as well as the CO2 emission by using HEV has been reported. Moreover, the commercial success of the Prius HEV by Toyota has confirmed the claimed advantages. Due to the success of Toyota, other manufacturers have begun to develop their own HEV technology. However, the market of HEV technology is not limited only to the market of new cars. Converting conventional vehicle to HEVs is a high potential market. Retrofitting a used car will be also an interesting choice for people who wish to use the HEV technology in a low price.

Electric vehicle is an automobile propelled by one or more electric motors, drawing power from an onboard source of electricity. Electric cars are mechanically simpler and more durable than gasoline-powered cars. They produce less pollution than do gasoline-powered cars. An electric car stores its energy on board-typically in batteries, but alternatively with capacitors or flywheel storage devices.

The aim of this work is to develop and prove the retrofitting concept to transform conventional vehicle to HEVs. This paper presents the design concept, the methods of dimensioning components including the hardware layout and simulation results were placed in the documentation.

2. LITERATURE REVIEW

2.1 MODELING AND SIMULATION

Karen et al (1999) presented a simulation and modelling package developed at Texas A&M University, V-Elph 2.01. V-Elph was written in theMatlab/Simulink graphical simulation language and is portable to most computer platforms. They also discussed the methodology for designing vehicle drive trains using the V-Elph package. An EV, a series HEV, a parallelHEV and a conventional internal combustion engine driven drive train have been designed using the simulation package. Simulation results such as fuel consumption, vehicle emissions, and complexity are compared and discussed for each vehicle. a Xianmin (2002) developed a novel propulsion system design scheme for EVs requiring high power density. The theory analysis

Brian (2007) created a model in MATLAB and ADAMS to demonstrate its fuel economy over the conventional vehicle. He used the Honda IMA (Integrated Motor Assistant) architecture, where the electric motor acts as a supplement to the engine torque. He showed that the motor unit acts as generator during the regenerative braking. He used a simple power management algorithm in the power management controller he designed for the vehicle. Cuddy and Keith (2007) performed a parallel and series configured hybrid vehicles likely feasible in next decade are defined and evaluated using flexible Advanced Vehicle Simulator (ADVISOR). Fuel economies of two diesel powered hybrid vehicles are compared to a comparable technology diesel powered internal combustion engine vehicle. The fuel economy of the parallel hybrid defined is 24% better than the internal combustion engine Vehicle and 4% better than the series hybrid

2.2 CONTROL SYSTEM

The effectiveness of fuel consumption depends not only on vehicle design but also on the control strategy used. The control strategy provides a dynamic control of the vehicle to ensure the best utilization of the onboard energy resources for the given operating conditions. So, the energy management strategy is extremely important to decide how and when energy will be provided by various sources of PHEV. In 1999, AVL Company proposed a hybrid system that used a 50 cccarburetted lean-burn two-stroke engine with a 0.75 kW electric motor mounted on the engine crankshaft mainly to provide increased torque during acceleration.

Yimin and Mehrdad (2006) introduced a speed and torque coupling hybrid drive train. In this drive train, a planetary gear unit and a generator/motor decouple the engine speed from the vehicle wheel speed. Also, another shaft-fixed gear unit and traction motor decouple the engine torque from the vehicle wheel torque. Thus, the engine can operate within its optimal speed and torque region, and at the same time, can directly deliver its torque to the driven wheels. They also discussed the fundamentals architecture, design, control, and simulation of the drive train. Simulations show that the fuel economy in urban and highway driving cycles can be greatly improved. Kuen-Bao and Tsung-Hua (2006) incorporated a mechanical type rubber V-belt, continuously-variable transmission (CVT) and chain drives to combine power of the two power sources, a gasoline engine and an electric motor in hybrid power system. The system uses four different modes in order to maximize the performance and reduce emissions: electric-motor mode; engine mode; engine/charging mode; and power mode. The main advantages of this new transmission include the use of only one electric motor/generator and the shift of the operating mode accomplished by the mechanical-type clutches for easy control and low cost. Kinematic analyses and design are achieved to obtain the size of each component of this system. A design example is fabricated and tested.

2.3 ELECTRIC PROPULSION AND ENERGY STORAGEDEVICE

In the area of propulsion motor and other motor control technologies, methods to eliminate speed/position sensors, inverter current sensors, etc., have been under investigation for several years. The technological challenges for the electric motors will be light weight, wide speed range, high efficiency, maximum torque and long life. Most hybrid hardware subsystems and components with exception of energy storage devices have been matured to an acceptable level efficiency performance and reliability. As per the studies, the energy stored in the HEV storage unit is much smaller than that in the EV unit. It is also clear that the power capability of the batteries designed for HEVs is much higher than those designed for EVs. However, batteries for plug-in hybrid electric vehicles require both high energy density and high-power capability based on the driving requirements. The other significant technical challenges include higher initial cost, cost of battery replacement, added weight and volume, performance and durability.

2.4INFLUENCE OF DRIVING CYCLE

Sukanya et al (2006) proposed a method to develop a driving cycle representing the Bangkok traffic. A method for selecting the representative road routes in Bangkok was firstly proposed. A gasoline passenger car equipped with a real time data logger was then used to collect speed-time data under actual traffic along the selected road routes in Bangkok urban area for two months. The driving characteristics were analyzed from the speed-time data and its target driving parameters were defined and evaluated. The method for generating the driving cycle was then proposed and described. After achieving a driving cycle, exhaust emissions and fuel consumption of a vehicle were measured by driving a car on a standard chassis dynamometer according to the obtained Bangkok driving cycle. Comparison of the exhaust emission test and fuel consumption test results obtained from the constructed driving cycle with those obtained from the presently-adopted European standard cycle had been made.

3. METHODOLOGIES

OBJECTIVES AND METHODOLOGY

3.1 OBJECTIVES

The objectives of the research work are stated as follows.

i) To develop a simple vehicle model and simulation for sizing of power train components followed by selection of power train components.

ii) To propose and develop a simple control strategy for the plug-in hybrid electric four-wheeler suitable for city driving conditions.

iii) To develop a plug-in hybrid electric four-wheeler by converting available conventional four-wheeler with a suitable motor and battery.

3.2 METHODOLOGY

To achieve the above stated objectives, the following methodologies are to be used.

i) A Simulink simscape vehicle model will be developed and MATLAB simulation will be carried out for evaluation of power and energy requirements for a plug-in hybrid electric four-wheeler for different driving cycles.

ii) A simple control strategy has to be developed for Indian city driving conditions with less fuel consumption for reducing emissions.

iii) A conventional four-wheeler will be converted into a plug-in hybrid electric four-wheeler by retrofitting a hub motor in the rare wheel.

4. ELECTRIC VEHICLE

4.1 Introduction about Electric Vehicle

A more recent development is the hybrid electric vehicle (HEV), which uses both an electric motor or motors and a gasoline or diesel engine, which charges the batteries in order to extend the car's range and often to provide additional power. Regardless of the energy source, an electric car needs a controller, which is connected to the accelerator pedal, for directing the flow of electricity from the energy source to the motor. Most electric cars use lead-acid batteries, but new types of batteries, including zinc-chlorine, nickel metal hydride and sodium-sulphur, are becoming more common. The motor of an electric car harnesses the battery's electrical energy by converting it to kinetic energy. The driver simply switches on the power. selects "Forward" or "Reverse" with another switch and steps on the accelerator pedal While the internal-combustion engine of a conventional car has many moving parts and must convert the linear motion of pistons and rods into 140 rotary motion at the wheels, an electric motor has only a single rotating element. Like a gasoline-powered car, an electric car has a system (called a power train) of gears, shafts. and joints that transmit motion from the motor to the car wheels. Most electric cars do not have clutches or multi speed transmissions. In order to go backward, the flow of electricity through the motor is reversed, changing the rotation of the motor and causing the power train to make the wheels rotate in the other direction.

4.2.1 Battery Electric Vehicles (BEV)

Battery Electric Vehicles, also called BEVs, and more frequently called EVs, are fully-electric vehicles with rechargeable batteries and no gasoline engine. Battery electric vehicles store electricity onboard with high-capacity battery packs. Their battery power is used to run the electric motor and all onboard electronics. BEVs do not emit any harmful emissions and hazards caused by traditional gasoline-powered vehicles. BEVs are charged by electricity from an external source. Electric Vehicle (EV) chargers are classified according to the speed with which they recharge an EVs battery. The classifications are Level 1, Level 2, and Level 3 or DC fast charging. Level 1 EV charging uses a standard household (120v) outlet to plug into the electric vehicle and takes over 8 hours to charge an EV for approximately 75-80 miles. Level one charging is typically done at home or at your workplace. Level 1 chargers have the capability to charge most EVs on the market. Level 2 charging requires a specialized station which provides power at 240v. Level 2 chargers are typically found at workplaces and public charging stations and will take about 4 hours to charge a battery to 75-80 miles of range. Level 3 charging, DC fast charging, or simply fast charging is currently the fastest charging solution in the EV market. DC fast chargers are found at dedicated EV charging stations and charge a battery up to 90 miles range in approximately 30 minutes.

4.2.2 Plug-in Hybrid Electric Vehicle (PHEV)

Plug-in Hybrid Electric Vehicles or PHEVs can recharge the battery through both regenerative braking and "plugging in" to an external source of electrical power. While "standard" hybrids can (at low speed) go about 1-2 miles before the gasoline engine turns on, PHEV models can go anywhere from 10-40 miles before their gas engines provide assistance.

4.2.3 BACKGROUND HEV

Is defined as the technology in which there are more than one energy source used in which at least one source will be electricity. There are three main types of HEVs. All HEV systems are equipped with an electric motor, an ICE and a generator. They may be considered either series, parallel, or series-parallel depending on how the system is configured. Series hybrid is very similar to an EV, in that the electric motor moves the vehicle. The gasoline engine is there only to provide added power to the motor via the inverter, and acts as a range extender. A parallel hybrid is where the power to the drive train is shared by ICE and the motor

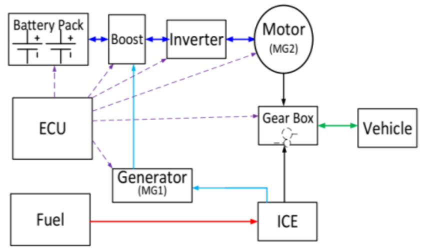


Figure: 4.1 Series-Parallel HEV Drive Block Diagram

HEV's series-parallel combination of electric drive is powered by a battery and a mechanical drive using the legacy ICE engine powered by fuel. The wheels can be driven by ICE engine and electric traction motor. Both systems are connected to the drive shaft of the vehicle.

Figure: 4.2 Series-Parallel Hybrid Drive System

The required power produced by the ICE is through the combustion of fuel as the source of power. For the traction motor, the source of power is the battery. The main idea here is to use electrical drive as long as possible, before the ICE must be used for longer journey, as required, to minimize use of fuel as much as possible. This concept requires the vehicle to use as big a battery as possible. However, due to size and weight limitations, battery is limited in the amount of energy that it can store in the space provided. In order to keep the currents low to minimize I2R losses in wires, battery is typically designed to be high voltage in the range of 200V to 500V

4.2.4 VEHICLE LOAD MODEL

Vehicle load can be a function of multiple variables, including aerodynamics. Here, we take into account the parameters that provide the largest effects on the vehicle in terms of load. Vehicle load model equations are below. Accelerating mass of vehicle will be the force on the wheels. Wheel force is then calculated as

$$f_{wheel} = M_T \frac{dv}{dt}$$

$M_T$is the total mass calculated as $M_T=M_{veh}+ M_{tire}$The torque on wheels can be determined as

$$T_{wheel} = r f_{wheel} = r\, M_T \frac{dv}{dt} = r\, M_T \frac{d(r\omega_{wh}}{dt}$$

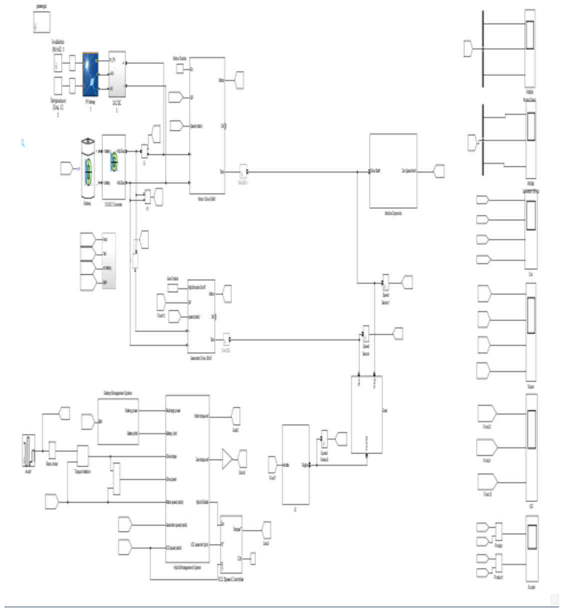
$$= r^2 \frac{d(\omega_{wheel})}{dt},$$

5. CHAPTER

MATLAB/Simulink Modelling

5.1 System Modelling

A system based model was developed by using SIMULINK library tool .The five main parts to the overall model are motor model, vehicle model, gear box model, control block model, and power balance and energy calculations. Complete high-level model of the system is shown below in Figure 13. Four main blocks that were developed as parts of the overall model are control, motor model, gear box and vehicle load model. Details of these blocks are discussed in the subsequent sections. Power energy block is simply used to calculate and store the input and output power and energy values during the drive cycle



5.2 Motor Modelling

A PMSM motor model was developed based on the state equations in d-q reference frame. This allows for easier control of the currents. The model uses the Park's transformed variables in d-q reference frame. Motor model is shown below in. Model developed here in Simulink is based on the state. These equations can be modelled using the blocks such as integrator, summing junction, multipliers, and dividers, to represent the full state equation. As an example, idsis the state output, Ld, Lq, and Rs are motor parameters which are constants, and vds andiqs are inputs.

5.3 Control Modelling

Proportional integral differentiator (PID) type controllers are quite common in the industry. This model uses a simple PI based control loop for vehicle speed control. Also, the q-axis current can be controlled in the same loop. The d-axis current is controlled to zero "0"amps, since only the q axis current produces torque. The gains, Kp and Ki, were chosen to provide a critically damped response to a step input, as well as a reasonable steady state error of less than 2%. This model consists of amplifiers, inverters and all other important functions which are used in the control systems to check the stability and characteristic of the model.

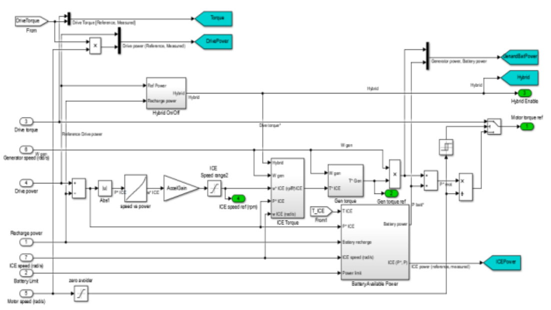


Figure: 5.3Simulink model of control system

6. CONCLUSION

In this research work, a conceptual model for retro-fitting a conventional vehicle into a plug-in hybrid vehicle is studied. Various power sources were studied and implemented based on the conceptual requirement in the module. Various simulations were executed to analyse the performance of the proposed implementation in the vehicle in converting plug-in hybrid vehicle. The simulations were studied and a successful concept was proposed in converting a conventional vehicle into a HEV. The proposed concept can be implemented in existing in conventional vehicle system to upgrade BS4 configurations into successful BS6 configurations to meet pollution standards and other standards can be met. To increase the engine efficiency and vehicle's overall efficiency based on futuristic applications; effective battery management (than the proposed battery system), Electrical Brake control, and security system can be studied and implemented for plug-in Hybrid vehicle.

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