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Optimal Drive Cycle Control for Energy Storage Systems in Parallel Hybrid Electric Vehicle

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ABSTRACT

In HEVs, maintaining high energy density is a necessity while demanding higher peak power as well thus this results in doubling the incremental cost of the vehicle if approx. 15 % of all electric range is demanded. The SOC of the vehicle directly affects the economy and the emission rates. In this work the parallel HEV is modelled by using ADVISOR and Different SOC limits are taken for testing the performance and fuel economy for the same designed driving cycle. With the simulation results we will be able to specify best upper and lower limits of SOC such that vehicle will achieve best fuel economy and emission performance. The simulation is performed by taking repetitive velocity profiles (drive cycles) of four different curves i.e. UDDS, ECE, FTP and HWFET. The operating effectiveness of the parts must be optimised by taking the system as a whole into account. The forward-looking approach will be used to carry out the control strategy. In this technique, the operating efficiency is maximised in order to maximise fuel economy; other strategies do not have this additional component. In order to improve fuel economy, the ability controller for parallel hybrid automobiles is mentioned in this study. The older power controllers that were installed optimise operation but do not fully utilise the possibilities.

Keywords: *Electric Range; Soc; Velocity Profile; Control Strategy; Performance; Operating Efficiency.*

1.0 Introduction

The majority of commercially available HEVs have an all-battery ESS that is connected by a bidirectional converter to a high-voltage dc bus. In order to expand the range of electric vehicles, the battery pack's capacity must be increased to store adequate energy[1]. In electric vehicles, ESS should be able to meet the total power consumption of the vehicle. Several authors have developed topologies to hybridise ESSs for EVs, HEVs, FC hybrid vehicles (FCHVs), and PHEVs in order to increase miles per gallon efficiency. The Toyota Prius, Honda Insight, and Ford Escape are examples of commercially available HEVs with fuel efficiency of about 40 mpg. In order to increase fuel efficiency and reduce emissions, hybrid electric vehicles provide additional flexibility [2-3]. In order for the HEV to operate effectively, an electric motor is linked with the electrical energy storage. Due to the linkage of the bidirectional converter, a two-power path was made available, allowing the engine to be cut off during low power operation as well as the use of a smaller, more efficient engine for this kind of vehicle. This is possible while maintaining the average power carrying capacity of the vehicle [5]. By accepting the extra power generated by the engine's effective operation, the electrical

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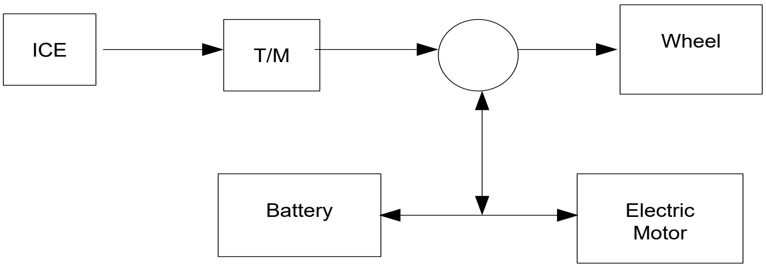
energy in the battery or any other energy storage device is kept constant during this process. Regenerative braking, in which kinetic energy is converted into electrical energy and stored, also aids in recharging the energy storage system [6]. One of the ESS that is utilised the most is batteries. A battery-based ESS, however, has a variety of challenges, leading researchers to look for alternatives. The power density of the batteries used in battery-based ESSs must be sufficient to meet the peak power demand.

2.0 Parallel HEV Basic

A parallel hybrid vehicle's IC engine, transmission, and EM connections are shown in Figure 1 as a block diagram. The power flow affects how various systems function, including: battery charging, where one part of the ice power is used to drive the EM as a generator and another part is used to drive the wheels; and regenerative braking, where the vehicle is slowed down and the EM is used as generator[7-8]. We can provide power with only ice, with only an electric motor, by using the internal combustion engine and the EM simultaneously.

It suggests that a parallel HEV system's performance is significantly influenced by how this power split is managed. Simple rule-based or map-based heuristic control strategies seem to be falling behind controllers that are oriented on minimising fuel consumption[9]. The latter, commonly known as optimal controllers, actually provides more generality and reduces the need for significant adjustment of the control parameters[10].

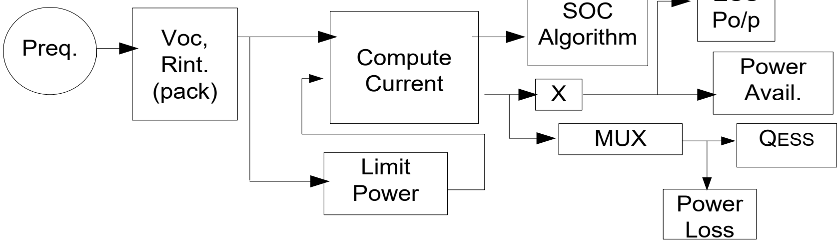
Figure 1: Schematic of Parallel HEV



3.0 System Configuration

The system configuration is shown in the schematic figure, where the battery pack is represented by the charge reservoir and the remaining charge is the circuit parameter[11]. The charge that an ESS contains is thought of as a constant amount, and the coulombic efficiency is what determines how well batteries are refilled. The only amount that can be provided by the battery is the maximum amount of power that the equivalent circuit or controller can tolerate under the circumstances of the lowest voltage requirements[12].

Figure 2: Schematic Block Diagram of ESS Model



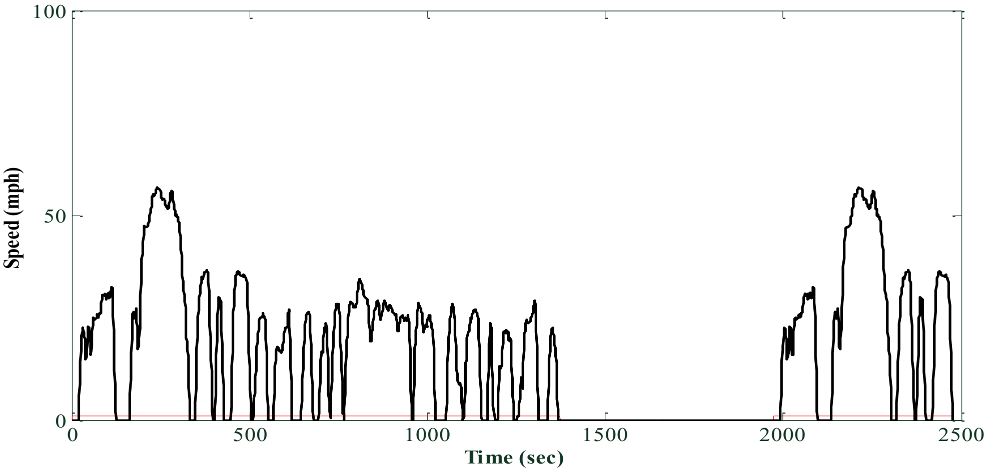
4.0 Simulation Results

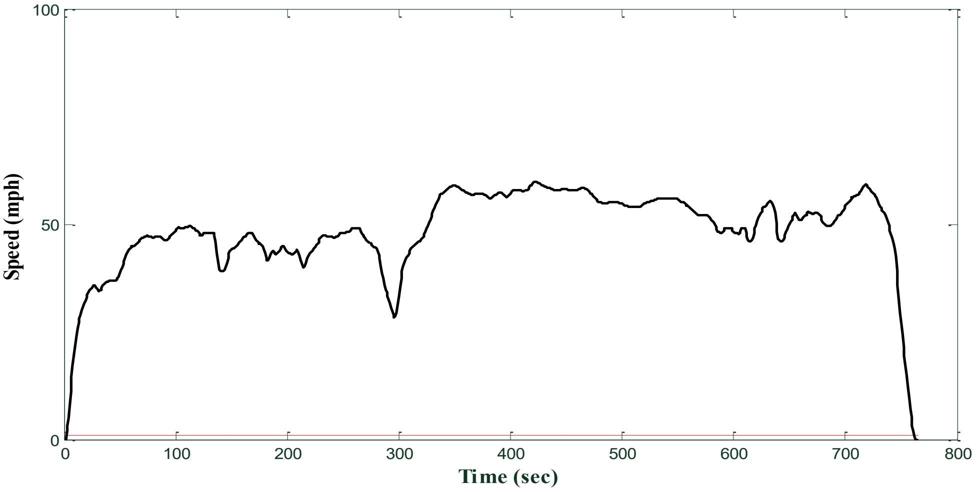
The vehicle is simulated with the following parameters given in the below table -

Table : Vehicle Parameters

Vehicle weight	15000 Kg
Motor ratings(power)	43 KW
Torque	200 nm
Engine ratings	120 hp
Battery pack	VRLA
Battery capacity	110 Ah
Terminal voltage	145 V

One half of the simulation is performed for the lower limit of SOC, and the other part is performed for the top limit of SOC. As too low or too high a value of SOC can harm the battery, it is necessary to maintain the practical limits of 20 to 80 percent. We form groups for the upper limit, or the end point, run separate simulations, and attempt to determine which group's soc range is optimal.As it depends on the initial values of SOC, the two crucial aspects that are taken into consideration are the engines' operating procedure and overall fuel usage.





5.0 Conclusion

In order to increase fuel efficiency and reduce emissions, hybrid electric vehicles provide additional flexibility In order for the HEV to operate effectively, an electric motor is linked with the electrical energy storage. Due to the linkage of the bidirectional converter, a two-power path was made available, allowing the engine to be cut off during low power operation as well as the use of a smaller, more efficient engine for this kind of vehicle. This is possible while maintaining the average power carrying capacity of the vehicle . Energy storage units are charged when there is a low demand for electricity, and they are discharged when there is a high demand. The component that controls the electric range and fuel economy is the ESS.

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