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Fuel Economy Optimisation by Utilising Hybrid Energy Storage Systems

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ABSTRACT

The onboard energy-storage system (ESS) of hybrid electric vehicles (HEVs) has a significant impact on their fuel efficiency and all-electric range (AER). Energy-storage Devices charge when there is little demand for electricity and discharge when high power requirements that operate as catalysts to boost energy. In ground vehicles, batteries serve as the main energy storage mechanism. Vehicles with an AER of 15% or more almost twice the added expense of the ESS. As the result ESS requires more peak power while maintaining high energy density of HEVs. In comparison to batteries, ultracapacitors (UCs) are the solutions with better power densities. For more advanced hybrid vehicular ESSs, a hybrid ESS made of batteries, UCs, and/or fuel cells (FCs) would be a better choice. Modern energy-storage architectures for HEVs and plug-in HEVs are presented in this work (PHEVs). In this paper, battery, UC, and FC technologies are examined and contrasted. Additionally, different hybrid Also discussed are different hybrid ESSs that integrate two or more storage devices.

Keywords: *Onboard Energy Storage; Hybrid Electric Vehicles (HEVs); Catalyst; Energy Density; Battery; Plug-in HEVs (PHEVs); Ultracapacitor(UC).*

1.0 Introduction

Hybrid electric vehicles' (HEVs') efficiency and all-electric range (AER) depend on the energy-storage system's (ESS) capacity, which is used to store huge amounts of energy but also needs to be able to release it fast in response to load demands [1]. Energy density, power density, lifetime, cost, and maintenance are some of the crucial features of automotive ESSs. Currently, the most popular choices for vehicular ESSs are batteries and ultracapacitors (UCs). The majority of the onboard electric energy is often stored in batteries, which have high energy densities. Contrarily, UCs have high power densities, a long life cycle, great efficiency, and quick response times for charging and discharging [2-3]. Another clean energy source is the fuel cell (FC), although the FC's performance on moving objects is constrained by its high time constant. No single energy-storage system can now fulfil all the needs of HEVs and electric automobiles (EVs). Hybrid Several energy-based storage technologies, including electrical, mechanical, chemical, and thermal. One store (ES1) in a HESS is often set aside to handle "high power" demand, transients, and quick load variations, and as a result, it has a quick response time, long cycle lifetime. Currently, batteries and ultracapacitors are the most often used options for car ESSs. The majority of onboard electric energy is stored

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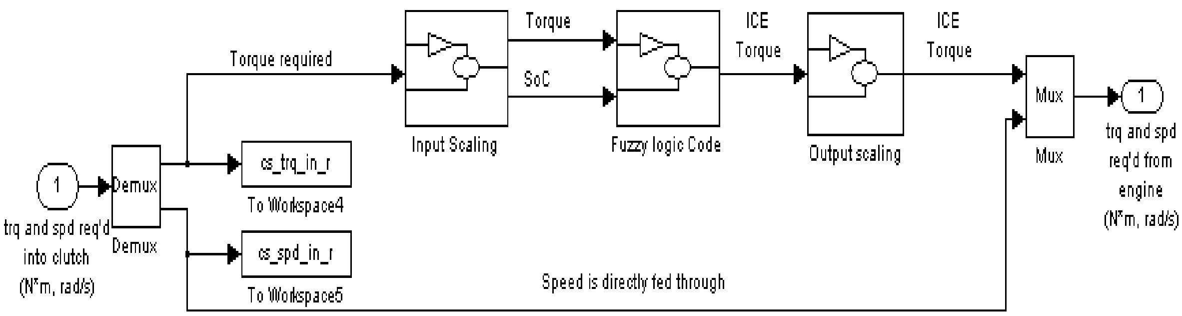
in batteries, which have high energy densities. Conversely, UCs feature high power densities, excellent efficiency, a long life cycle, and a rapid charging/discharging reaction. Automotive ESSs must have some basic characteristics, including energy density, cost, lifetime, and maintenance [4]–[5]. Another renewable energy source is a fuel cell (FC), albeit due to its high time constant, its performance on vehicles is constrained. For yet, neither HEVs nor electric vehicles have a single energy storage solution that can meet all of their requirements (EVs).

2.0 Controller Model & Description

The region where the ic engine will achieve peak efficiency is targeted in order to have control on the HEV . This will help enhancing the efficiency of the power train by having two modes of operation which are efficiency and fuel use. The value of momentary use of fuel is taken in the earlier mode and by doing so we can have the optimized economy which limited by map of fuel use and for efficiency purpose consumption of fuel is calculated. The engine is allowed to operate in the region of its peak efficiency [6-7]

Advanced vehicle simulator models are used to simulate the parallel HEV in Matlab/Simulink for controller analysis. These models were created using NREL's guidance and assistance. It is more appropriate because a forward-facing approach is used rather than a backward-facing design[8-9]. The driver is able to modulate the accelerator and brake pedals by monitoring the speed versus time profile. The directives to the power controller are computed using the driver inputs.

Figure : Schematic of Controller Model



3.0 Result & Discussion

Based on the model, the results of the analysis are presented and compared with the help of the below given table. The vehicle parameters taken for the analysis are also listed.

Table 1: Vehicle Parameters for the Analysis

Component	Parameter	Value
Vehicle	Veh_Cargo mass	135 kg
	Veh_Glider mass	590 kg
ESS	Li-ion	262
	VRLA	315
	Ultra-cap	42
	Ni-Mh	330
	Ni-Cad	162
	Ni-Zn	305

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The following figures shows the different ESS characteristics having their SOC variation with the internal resistance. The different technologies including Li-ion, Lead Acid , are shown for their SOC(State of Charge) variation in the figures 2(a) and 2(b) respectively.

Figure 2.a: Li-ion Battery Variation of SOC

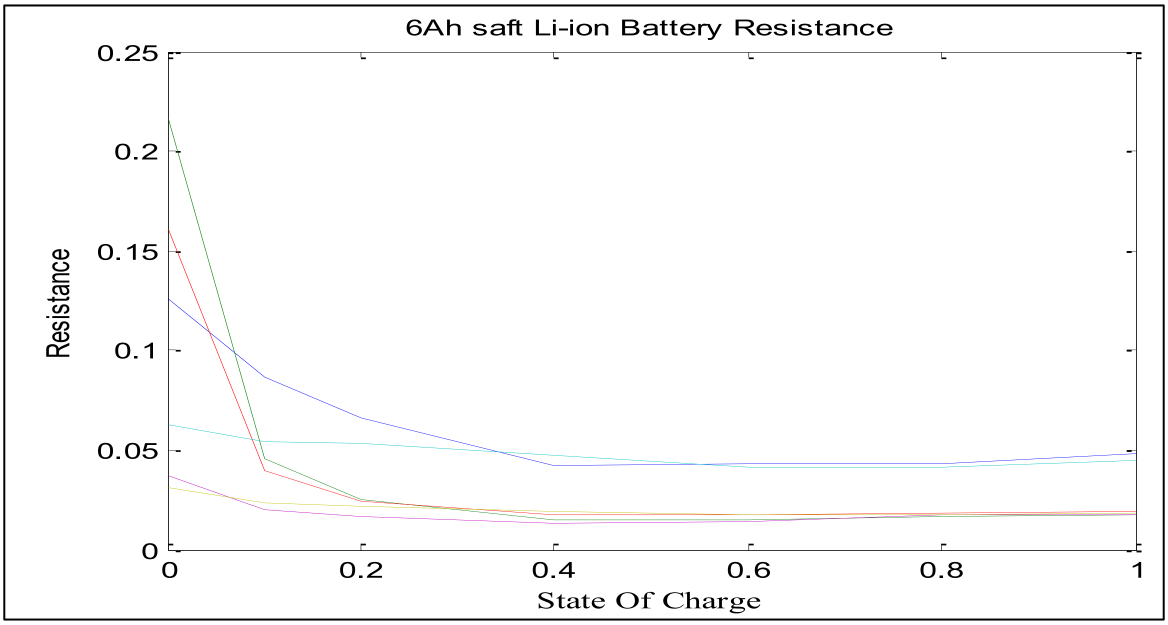
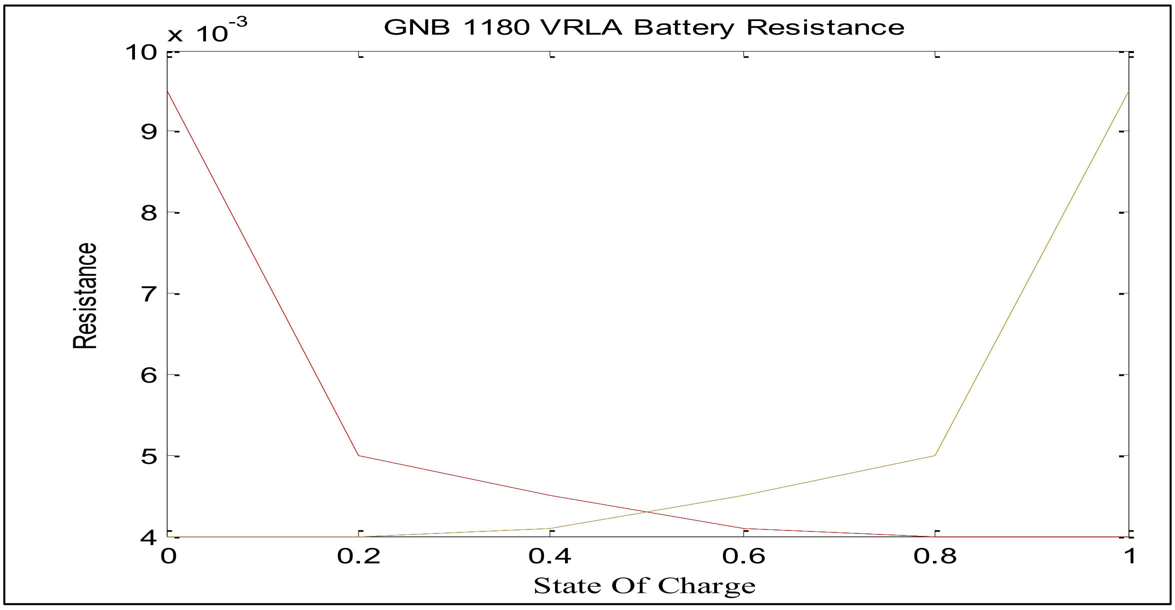


Figure 2.b: Lead Acid battery Variation of SOC



In these figures it is shown that for nickel-based batteries, larger changes have been noticed. The Ni-Mh battery shows the inverse relationship of SOC and internal resistance. It Infers that higher performance of battery cannot be achieved just after the full charge. For nickel cadmium, there is lower value of internal resistance and for Ni-Mh it is higher. For better understanding a table having specifications listed in the table are shown below

Table 2: ESS Specifications

Parameters/ESS	VRLA	Li-ion	Ni-MH	NiCad	Ni-Zn
Voltage (Max)	16	12	15.65	7	14.2
Voltage (Min)	10	6.2	9.15	5.88	6.63
Capacitive module	665	796	832	772	1178
Effective res(off)	0.642	7.84	1.60	0.842	3.210
Effective res(on)	0.365	1.14	0.52	0.35	0.40

The Nickel based batteries are more complex for charging as compared to Lithium or lead acid batteries . During a round trip , Li-ion battery lost approx. 5 % of energy i.e giving around 95 % efficiency .

4.0 Conclusion

HESS technology is very interesting as well as promising and it is helpful in short- or long-term fluctuations. The vehicle is dependent on energy storage systems thus it is very crucial to select best ESS according to the required application. The conventional lead acid battery is proved for the highly efficient and reliable storage system with minimal maintenance requirement. The lithium-ion battery has higher storage capacity as well as high horse power demand. High rate of charging is the requirement of Ni cadmium battery and it also have lower internal resistance with higher discharge cycle. But the longer life time is the advantageous feature in this system. The Li-ion battery has very popular attributes like it have longer lifetime, weight effective , faster recharging process etc which makes it best choice . But after analyzing all other ESS we can say that if one ESS is better in some way then other have some additional features. Hence any ESS can not replace other one completely which makes the HESS as the effective and better way for the effective automotive technology.

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