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Performance of Energy Storage Systems for Parallel Hybrid Electric Vehicles

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Abstract—*In this paper an alternative energy storage systemof a hybrid electric vehicle is investigated by considering baseline specifications. The battery is the main energy storage for electrical energy and is directly connected to the DC-bus. Consequently, charge and discharge is directly dependent on the DC voltage and the open circuit voltage (VOC) of the battery. The VOC depends on several parameterss, including battery type, number of series/parallel connected cells, temperature and state of charge (SOC)[1]. During normal operating conditions, the variation in VOC is rather small. The SOC is a parameter describing the relative amount of stored energy in the battery.In order to verify the simulation results, a downscaled HEV drive train consisting of NiMH/Nicd ,*Li^+*ion and LA batteries are tested with on-road vehicle data. The results show a SOC variation of battery.*

Index Terms: *Batteries, Drive train, power electronics, on-road test, baseline specifications.*

I. INTRODUCTION

This battery-EC system has been proposed already in the early nineties, but has not been put into production due to the complexity and, onto now, expensive design. Development has, however, accelerated during the past decade, yielding better performance and lower prices. Alternative fuels by the Energy Policy Act of 1992 and are currently, or have been, commercially available for vehicles are Biodiesel, Electricity, Ethanol,Hydrogen,Methanol,Natural Gas,Propane[2].Several emerging fuels are currently under development. Many of these fuels are also considered alternative fuels and may have other benefits such as reduced emissions or increased energy security are Biobutanol,Biogas,Biomass to Liquids (BTL),Coal to Liquids (CTL),Fischer-Tropsch Diesel,Gas to Liquids (GTL),Hydrogenation-Derived Renewable Diesel (HDRD),P-Series,Ultra-Low Sulfur Diesel.

II. POWER TRAIN OF A HYBRID ELECTRIC VEHICLE

The power train of an HEV is simplified in order to find appropriate models of each component. In general, there are two main design topologies of an HEV, the series design and parallel design. The parallel hybrid vehicle has an ICE and an electric motor with battery connected in parallel. The vehicle can be directly driven either from the ICE or the electric motor, or both at the same time(depending upon the % of power distribution).

The parallel HEV POWER train used in this investigation is presented in Fig. 1.

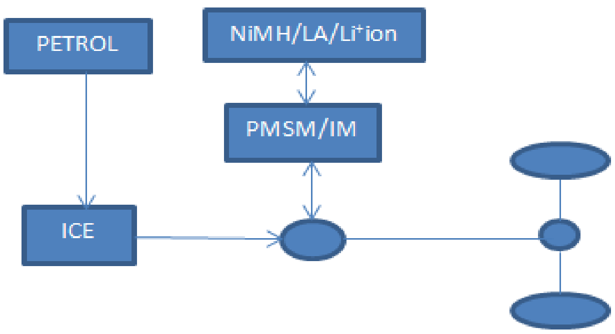


Fig 1: Parallel Hybrid electric vehicle Block Diagram

A.Storage

Batteries will last longer if stored in a charged state. Leaving an automotive battery discharged will shorten a battery's life, or make it unusable, if left for an extended period (usually over several years). Batteries in storage may be monitored and exponentially charged to retain their capacity. Batteries areprepared for storage by charging, cleaning of deposits. Batteries are generally stored in a cool dry environment.

Ratingsof batteries are commonly depends uponAmpere-hours (A·h), Cranking amperes (CA), Cold cranking amperes (CCA), Hot cranking amperes (HCA) and etc.

B.Motors

Motors for HEV requirehigh reliability, torque,speed and largepower to weight ratio.Induction motor and PMSM arewidely used for highefficiency, high power density, high torque/current unitsand wide-speed operation HEV driving system.

C.ICE

The engine is the primary source in parallel hybrid electric vehicleused for vehicle propulsion and the minimum speed values are taken intoaccount while the vehicle is decelerating whereas themaximum values are calculated for acceleration.Themaximum and minimum speed values of the generator andthe ratios of the planetary gear are the parameters whilecalculating engine speed. The other part of the planetarygear is the driving shaft, which is proportional to thevehicle's actual speed so it is taken as a definitive value forengine speed.

III. BATTERYTYPES USED FOR PARALLEL HYBRID VEHICLE

At present three types of batteries are widely used, includinglead acid (L-A), Ni-MH, and lithium-ion (Li-ion) batteries. Following the same order are theirimproved performance, energy density, and increased cost. For economic reasons, L-A batterieswere used in earlier production electric vehicles. Ni-MH is gaining popularities on present HEV.Meanwhile, Li-ion battery applications are mostly limited at present to smaller electronics devicesdue to its superior power density where cost is not as much of a factor. Li-ion batteries, as apromising technology for vehicle applications in the future, start to see applications in high-endlow speed vehicles [3].

<table>
<tr><td>Battery</td><td>Power Output</td><td>Ampere Hour rating</td><td>Voltage</td></tr>
<tr><td>Sealed Nickel-Metal Hydride (Ni-MH)</td><td rowspan="3">36 hp (27 kW)</td><td rowspan="3">6.5 Ah</td><td rowspan="3">200Vdc</td></tr>
<tr><td>Lithium-Ion battery</td></tr>
<tr><td>Lead-acid battery</td></tr>
</table>

IV. SIMULATION RESULTS

The open circuit voltage, is measured when the engine is off and no loads are connected. VOC was also determined for use in the MATLAB /SIMULINK model. Open circuit voltage is also affected by temperature, and the specific gravity of the electrolyte at full charge.

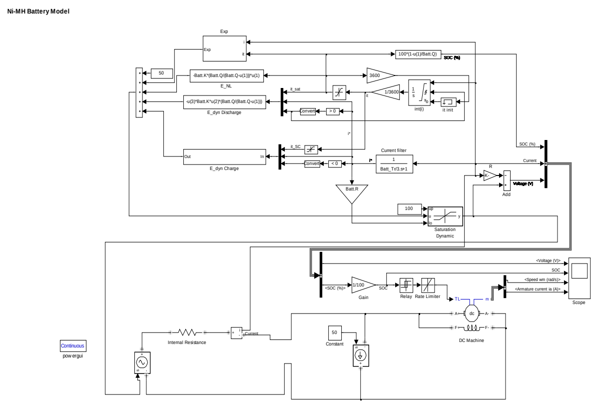
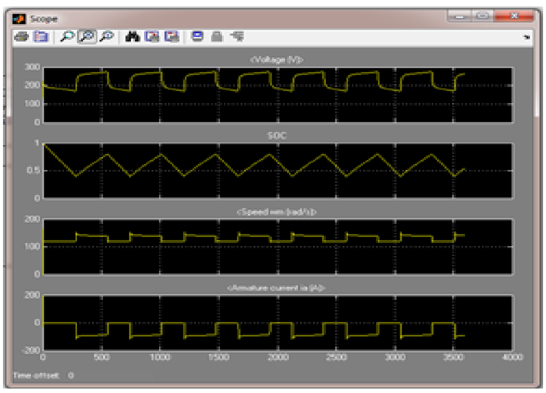
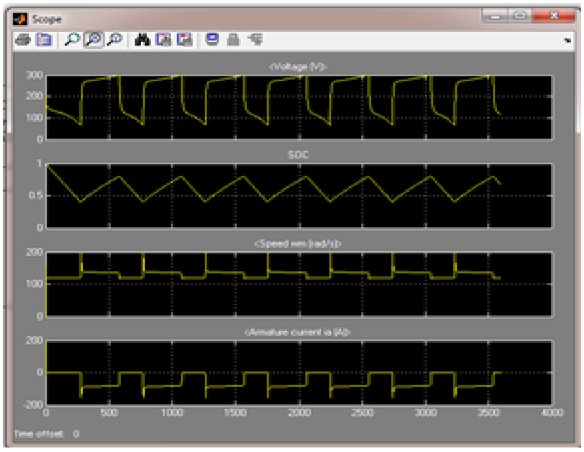


Fig 4: Battery Internal model

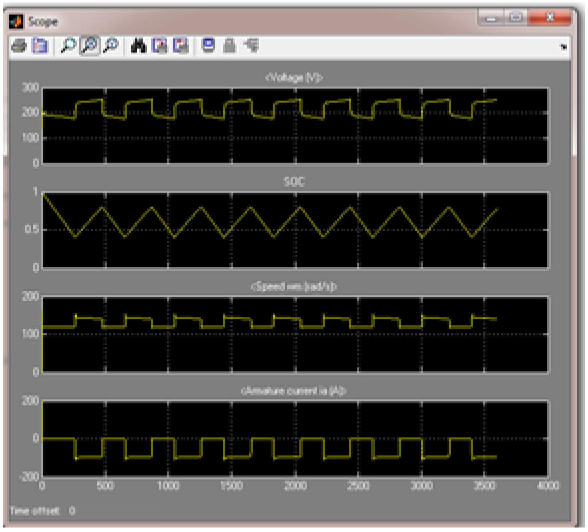
a) NiMH Battery



b) Lead acid Battery



c) Li+ion Battery



V. CONCLUSIONS

Hybrid electric vehicle markets are growing worldwide. Asfor hybrid electric vehicles compared with conventional cars have many advantageous.NiMH and Li-ion are thedominating current and potential battery technologies for higher functionalityHEVs like Toyota Prius and Honda civic.Soc variation with load variation under real world drivingconditions would provide an opportunity to realize fuel economybenefits comparable with NiMH and Li-ion technology inmild to medium hybrid applications. From the simulations results obtained in MATLAB-SIMULINK the Li^{+}ion is the best battery, which supports all the required of power splitting in parallel hybrid electric vehicle.

VI. ACKNOWLEDGMENT

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