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Research of Dependence of Hybrid Electric Vehicle’s Fuel Consumption on the Electric Drive Parameters

A question of saving fuel has been raised recently as there is increase in price for fuel that can make driving expensive in the near future. Another reason to reduce fuel consumption is environmental issue in cities. The increasing number of cars in cities causes more emission of lead and carbon dioxide to atmosphere. That is why, air is not only dirty, but also harmful in overloaded by traffic areas.

Hybrid electric vehicle (HEV) could be a solution of the problems in question. The powertrain of any HEV consists of three main parts: internal combustion engine (ICE), motor and energy storage [1, 2]. Optimal battery capacity is under consideration because of the price and weight of the energy storage which rises when capacity rises [3].

To preliminary determine the optimal energy storage capacity we first need to understand where and how energy is consumed in a vehicle. The cycle of vehicle’s movement in the city has a trapezoidal shape.

In HEV, unlike conventional vehicle, depending on capacity of the energy storage we could compensate some part of required power for acceleration in the first phase and in this way, reduce the consumption of fuel. Braking in HEV is usually realized by motor which switches to recuperation mode. Hence, accumulated kinetic energy turns into electric charge which is accumulated in a battery and then is used again for acceleration in the next cycle of movement.

Using a model developed by us in the package of MATLAB/Simulink we can explore the dependence of fuel consumption on battery capacity.

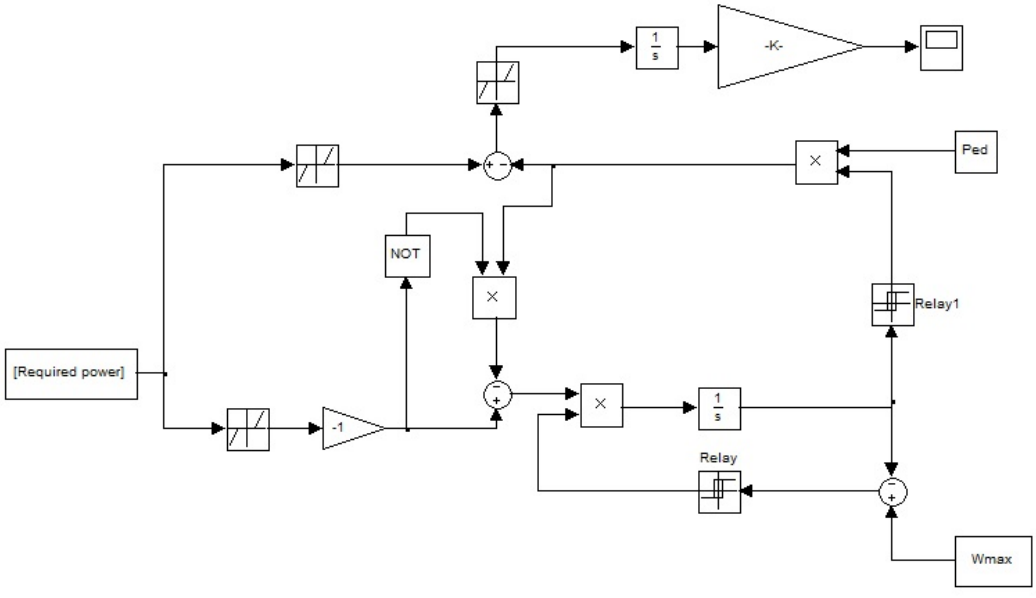

Figure 1 – Model of energy system of HEV in package MATLAB/Simulink

After carrying our research of dependence of fuel consumption on capacity of the battery for the average car with 1500-1800 kg weight (Daewoo Sens can be taken as an example), we have got the following dependence:

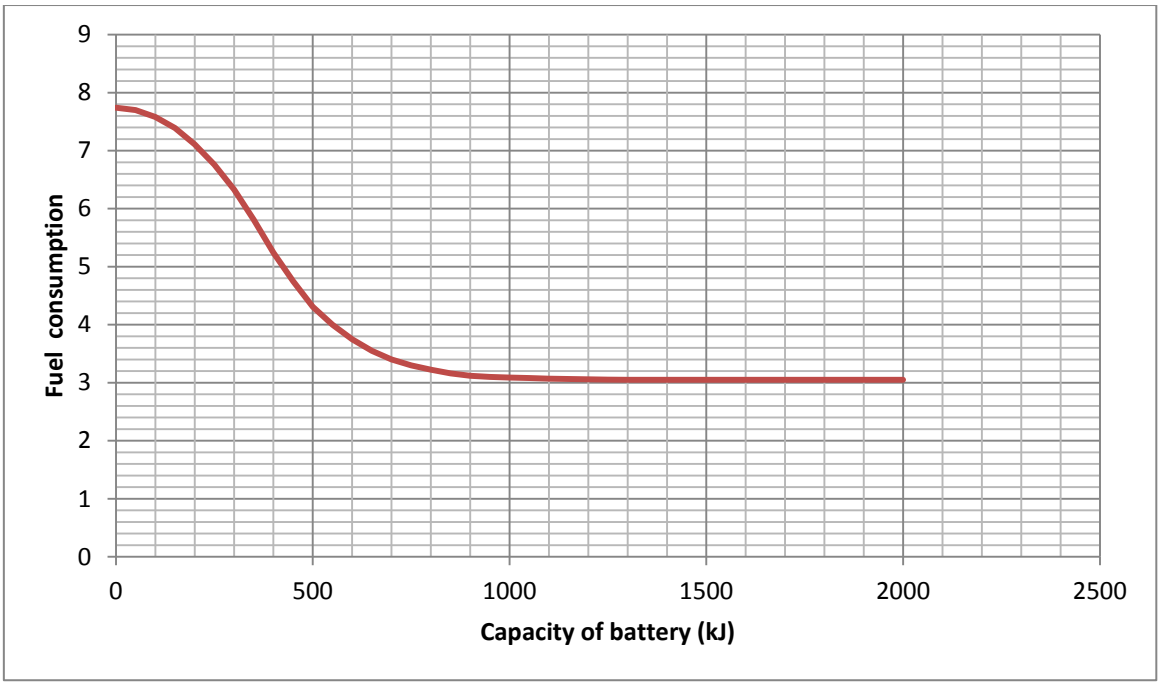

Figure 2 – Dependence of fuel consumption on capacity of the energy storage

As we can see from the graph, the rise of the battery capacity causes the reduction of average consumption of fuel for one hundred kilometer drive. However, we can see the consumption decrease up to 1000 kJ and further capacity increase doesn't cause significant fuel saving. This can be explained as lack of the recuperated energy to fill the battery after capacity increase. On one hand, battery will be charged only to a certain level. So, further capacity increase will not effect HEV's fuel consumption. On the other hand, price and weight will increase significantly.

To sum up, we can make a conclusion that for HEVs the most optimal capacity of the battery would be within 700-1000 kJ and in this way, we could reduce fuel consumption from 7.5 – 8 (liters/100km) to 3 – 3.5 (liters/100km).

References:

1. Muhammad H. Rashid (2010) *Modern electric, hybrid electric, and fuel cell vehicles fundamentals, theory, and design* (second edition): University of West Florida.
2. Iqban Husain (2005) *Electric and hybrid vehicles design fundamentals*: CRC Press, Taylor & Francis e-Library.
3. Paul Nelson, Khalil Amine, Hiroyuki Yumoto, Aymeric Rousseau (2008) *Advanced lithium-ion batteries for plug-in hybrid-electric vehicles*: Argonne National Laboratory, EnerDel Corp.