HYDROGEN HYBRID ELECTRIC VEHICLES

Ipatov A.A., Alioshin S.V., Khripach N.A.*, Lezhnev L.Y.
Federal research and development automotive and engine center "NAMI"
Avtomotornaya St., 2, Moscow, 125438 Russia
* *Fax: +7 (095) 456 70 97 E-mail: khripachna@yandex.ru*

Introduction

The depletion of natural energy sources, a constant increase in the price of petroleum–based fuels, global environmental pollution largely caused by an uncontrollable growth in the number of automobiles worldwide, tightening of the environmental regulations on the emission of hazardous substances by cars – all that calls for the development of ecologically sound automotive power plants with a minimal fuel consumption.

Results and discussions

The use of electrochemical generators based on fuel cells as power plants and hydrogen as fuel has been recognized as the most promising avenue to a decrease in the toxicity and consumption of fuels. The products of hydrogen combustion in electrochemical generators do not contain hazardous components. Their efficiency is higher than that of the traditional power plants.

There are currently two factors that hinder an extensive use of fuel cells in the automotive industry. They are their costliness and a limited mileage.

As far as the costliness is concerned, it is obvious that the price of electrochemical generators is determined by their production cost, a part of which is the cost of precious metals, their materials. It is unlikely that their cost will decrease with mass production. Therefore, here we consider another way of decreasing the cost of the electrochemical generator: reducing its size, which can be afforded by reducing its power capacity.

An insufficient mileage is caused by the lack of energy efficient storage capacities on board the vehicle. This issue is partly resolved by utilizing fuel processors which produce hydrogen in the vehicle proper. However, such systems have a fairly large thermal inertia. In order to condition an acceptable automotive dynamics, an intermediate energy accumulation buffer would be necessary.

There may be two options here – a hydrogen–based or an electrical buffer, the latter being a simpler and safer choice. The use of a buffer energy accumulator renders this power plant a hybrid one. When calculating hybrid power plants, one needs to pay a special attention to developing an algorithm of controlling the operation of its parts. As we can see from the energy calculation breakdown of the ZIL Bychok lorry, in order to conform to the driving cycle Regulation 83 of the UNECE, the power plant needs to deliver a capacity of up to 100 kW, with an average power capacity of 20kW in the cycle (fig.).

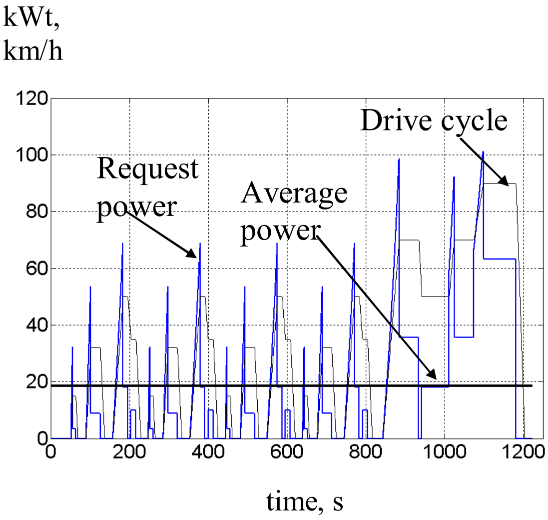

Fig. Vehicle power consumption

The best solution would be securing the operation of the electrochemical generator at a capacity equal to the average cycle capacity, while utilizing the buffer energy accumulators for an insufficient or excess energy when the vehicle is in motion.

In this scenario there is an opportunity to reduce the capacity of the electrochemical generator by five times and secure the operation of the fuel processor in its stationary and most efficient mode. The capacity of the buffer accumulators in this case needs to be at least 2.6 kW/hr. This format is ideal when a vehicle travels along a predetermined route, that is, when its average power capacity can be calculated beforehand. If the average power capacity of the vehicle in motion is different from that of the electrochemical generator, there may be a complete discharge of the accumulator or its overcharge, which would cause the electrochemical generator to work in the extremely undesirable idle mode.

For the general condition of the motion of a vehicle, which may entail a random unfixed process, we have developed an operational algorithm for the power plant, one that would allow to maintain the charge of the buffer accumulator at its maximum while minimizing the possibility of shifting the electrochemical generator into the idle mode and minimizing a complete drainage of the accumulator. Furthermore, the algorithm provides a gradual change in the capacity of the electrochemical generator when it is powered by a fuel processor with thermal inertia.

We have used the Matlab/Simulink applications when developing the strategy for controlling energy distribution.

Conclusions

Thus, the utilization of a combined power plant for the purposes of the electrochemical generator based on fuel cells and our proposed operational algorithms of the parts of [HEV] provides:

- a reduction of the maximum power of the electrochemical generator by 2 or 3 times, which would lead to an eventual decrease in the cost of the power plant
- a minimization of the capacity of the buffer energy accumulator
- an opportunity to utilize inertial fuel processors to power the electrochemical generators with hydrogen

References

1. V. F. Kamenev, N. A. Khripach, G. S. Kornilov A Hybride Vehicle with a Hydrogen Fuelled Power Installation // ISJAEE #2,2004, Russia, Sarov.

2. L. Lezhnev, I. Minkin Hybrid electric vehicles./ Automotive industry. 2003, p. 11-12.

3. L. Lezhnev, J. Buckland, I. Kolmanovsky. Boosted Gasoline Direct Injection Engines: Comparison of Throttle and VGT Controllers for Homogeneous Charge Operation. / SAE Technical Paper № 2002-01-0709, 2002 г.

4. Kamenev V.F., Khripach N.A. Future trends hydrogen energy of automotive vehicles / Proceedings of the Fourth International Conference "HTM-2004", Ukraine, Donetsk – 2004.