UDC 629.3+504

VALVE TURBO-ALTERNATOR AS ADDITIONAL HYBRID CAR DEVICE FOR THE HIGH-VOLTAGE BATTERY CHARGE

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Abstract. *The description of the hybrid car, its drive components and method of the solution of the problem with moving period of the car on electric pulling by means of valve turbo-alternator is given in this article.*

Key words: *Valve turbo-alternator, hybrid car, internal combustion engine, electric motor, high-voltage battery.*

ВЕНТИЛЬНЫЕ ТУРБОГЕНЕРАТОРЫ, КАК ДОПОЛНИТЕЛЬНОЕ УСТРОЙСТВО ЗАРЯДА ТЯГОВОЙ ВЫСОКОВОЛЬТНОЙ БАТАРЕИ ГИБРИДНОГО АВТОМОБИЛЯ

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Аннотация. *Дано описание гибридного автомобиля, узлов его привода и метод решения задачи движения автомобиля на электрической тяге посредством вентильного турбогенератора.*

Ключевые слова: *вентильный турбогенератор, гибридный автомобиль, двигатель внутреннего сгорания, электродвигатель, высоковольтная батарея.*

ВЕНТИЛЬНІ ТУРБОГЕНЕРАТОРИ, ЯК ДОДАТКОВІ ПРИСТРОЇ ЗАРЯДУ ТЯГОВОЇ ВИСОКОВОЛЬТНОЇ БАТАРЕЇ ГІБРИДНОГО АВТОМОБІЛЯ

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Анотація. *Наведено опис гібридного автомобіля, вузлів його привода і метод вирішення задачі руху автомобіля на електричній тязі від вентильного турбогенератора.*

Ключові слова: *вентильний турбогенератор, гібридний автомобіль, двигун внутрішнього згоряння, електродвигун, високовольтна батарея.*

Introduction

The given work is a description of the hybrid car, its drive component and method of the solution of the problem with moving period of the car on electric pulling by means of valve turbo-alternator (VTA), which will use the energy of exhaust gases for obtaining the additional electric power for high-voltage battery (HVB).

Analysis of publications

The hybrid car is an economical car, driven by system «electric motor (EM) – internal combustion engine (ICE) », supplied both by fuel and HVB charge. The hybrid uses ICE and electric motor together that enables to save fuel without losing its power [1].

The hybrid car is composed of the drive serving as ICE, valve motors/generators, high-voltage battery, axel differential, axis and wheels, drive noiseless chain and reducer, invertors and power split device (fig. 1).

The main advantage of hybrid car is reduction of the fuel consumption and poisonous exhaust. This is achieved by full auto control of engine systems by means of on-board computer [2].

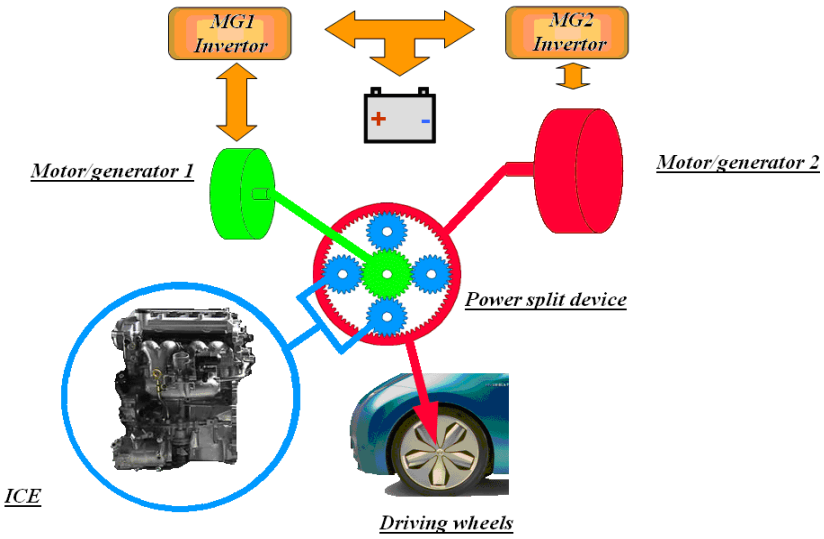

Fig. 1. Hybrid car drive components

When operating the hybrid car motion modes change depending on the car speed, driving style or from other external factors.

There are 3 types of the hybrid cars:
1 – Consequent;
2 – Parallel;
3 – Consecutively – parallel.

Design and a work principle of valve electric motor in the hybrid car

The valve electric motor (fig. 2), in fact, is a synchronous reversible contactless car of a direct current. The efficiency of such engine is more than 90%. Such high efficiency is caused by the presence of super-power constant magnets in a rotor. These magnets are alloys of NdFeB [3].

The electric motor/generator consists of a stator, a rotor with constant magnets, the rotor position gauge and an electric motor control system.

The electric motor/generator stator consists of the case, the core made of electro-technical steel and the copper winding laid in chases on perimeter of the core. There are three windings of this kind.

The electric motor/generator rotor is made with the use of three pairs of constant magnets with alternation of northern and southern poles. The rotor position gauge carries out a feedback according to the position of rotor. The principle of its work is based on the Hall Effect.

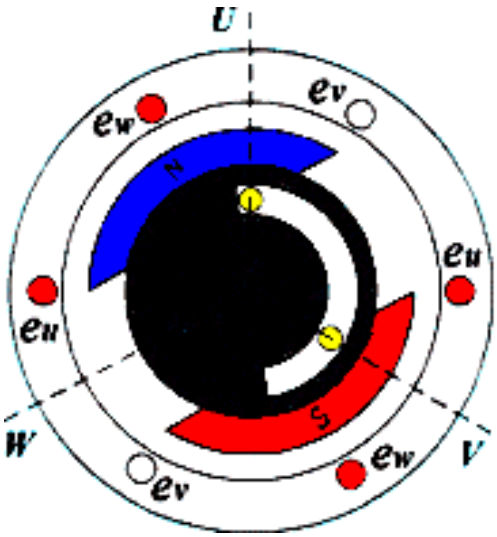

Fig. 2. Valve electric motor

An essence of a given method of additional charge of the high-voltage battery with the help of valve turbo – alternator

The essence of a given method of additional high-voltage battery charge lies in using energy of hybrid car exhaust gases by its transformation into electric power with a help of the valve turbo-alternator.

The VTA is a device that consists of a turbine and a valve generator fitted on one shaft, a diode bridge block, a voltage adjuster, a system of throttle valves with an electronic control package. Turbine consists of heat resisting and light metal alloys. The generator itself consists of a stator and a rotor with constant magnets.

It is desired to place the turbine in exhaust manifold of ICE. Speed of exhaust gases in an exhaust manifold reaches 100 m/s that allow a turbine to rotate with the frequency of more than 80000 rpm. Energy of turbine rotation is transferred to a rotor through the shaft which creates alternate current in windings while rotating.

Such design of a VTA enables a hybrid car to cover longer distances on an electric pull as the process of HVB charge will take shorter time.

Estimations

Toyota Prius HW20 serves as an example to estimate additional HVB charge with the help of VTA.

HVB parameters:
– Rated voltage – 273.6 volts;
– Rated capacity – 6, 5 ampere-hours;
– Top discharge current – 80 amperes;
– Top charge current – 50 amperes;
– Rated charge voltage – 300 volts;
– Rated charge storage of HVB – 6.4 MJ;
– Rated HVB charge period under max voltage is 292,5 sec (Maximum electric engine power);
– Rated HVB charge period under max voltage is 468 sec (ICE idle work).

Rated HVB charge period is estimated under the formula (T_r, sec):

$$T_r = (C_r \div A_c) \times 3600,$$

where C_r – Rated HVB capacity, A × h;
A_c – HVB charge current, A,

$$T_r = (6{,}5 \div 50) \times 3600 = 468.0 \text{ sec.}$$

Parameters of designed VTA:
– Rated rotation frequency – 80000 rpm;
– Rated voltage – 300 V;

– Rated current – 20 A;
– Rated power – 6000 W.

Estimated period of HVB charge with use of VTA is as follows:

$$T_e = (C_r \div A\sum) \times 3600,$$

where C_r – Rated HVB capacity, A × hours;
$A\sum$ – Total HVB charge current, A,

$$T_e = (6{,}5 \div 70) \times 3600 = 334.2 \text{ sec.}$$

Period difference of HVB charge before and after VTA mounting (ΔT, sec):

$$\Delta T = T_r - T_e,$$

$$\Delta T = 468 - 334.2 = 133.8 \text{ sec.}$$

Reduction of HVB charge period by 28.5%

Conclusions

Having considered all estimations we can make a conclusion that the use of VTA reduces HVB charge period by 28.5% which in turn enables hybrid car to cover longer distances on electric pull, saving fuel and diminishing environmental pollution.

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Статья поступила в редакцию 23 июля 2009 г.