Достовірність побудованих моделей підтверджується проведенням порівняльного аналізу розрахункових та експериментальних даних, які узгоджувалися з результатами досліджень інших авторів.

Висновки

Статична модель ПД дозволяє визначити величини тиску стисненого повітря на впуску і фази газорозподілу для узгодження кривих потужності і крутного моменту при переході КЕУ між режимами роботи ПД і ДВЗ. Графічна інтерпретація результатів показала, що зі збільшенням тривалості впуску стиснутого повітря більш ніж 135 град. п.к.в. зміна потужності та крутного моменту не спостерігається. Для узгодження показників роботи ПД і ДВЗ необхідно застосовувати редуктор з плавним регулюванням тиску стисненого повітря та керованих електрогідравлічних клапанів для зміни кута початку та тривалості впуску стисненого повітря.

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ANALYSIS OF METHODS FOR DETERMINING THE OPTIMAL CONTROL OF AN ELECTRIC VEHICLE

Bazhynov Oleksiy, Professor of the Department of Technical Operation and Service of Vehicles, Kharkiv National Automobile and Highway University,
e-mail: alexey.bazhinov@gmail.com, ORCID: 0000-0002-5755-8553
Maria Vesela, Dipartimento di Economia, Impresa, Matematica e Statistica, Università degli Studi di Trieste, Italia,
e-mail: mves357@gmail.com, ORCID: 0000-0001-9318-9110

Introduction

The need to protect the environment is having an increasingly important impact on the development of the automotive industry. The task of eliminating the damage caused by modern cars, i.e. exhaust gas pollution, is becoming more urgent. The growing level of air pollution in large cities has raised the issue of developing a set of measures to reduce the content of toxic substances in the atmosphere.

The bulk of toxic emissions into the atmosphere are accounted for by road transport. This leads to requirements for the automotive industry to reduce the level of toxic substances emitted during vehicle operation. Given the analysis of the global automotive market, it can be concluded that electric vehicles and vehicles with electric power plants are currently becoming a serious alternative to basic vehicles with internal combustion engines.

Research materials

An electric vehicle is a vehicle driven by one or more traction electric motors, which are powered by traction batteries rather than internal combustion engines. In addition to harmful emissions in the form of chemicals and compounds, internal combustion engines are inefficient.

In the balance of the heat energy released by a car engine, only about 12% is actually spent on movement, and the remaining 88% of the heat energy is wasted through various car devices into the external environment. And the efficiency of traction electric motors reaches 98%. That is why leading countries are intensively searching for rational technical solutions to create promising models of electric vehicles and directing all efforts to their industrial production.

A block diagram of the main components of an electric vehicle is shown in Fig. 1.

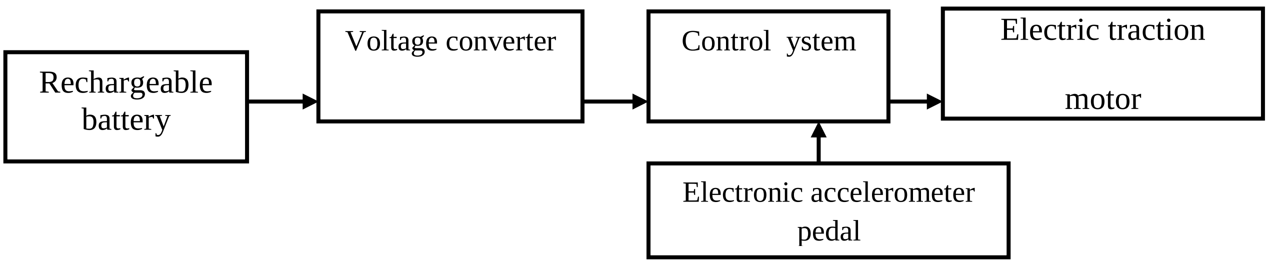

Figure 1.1 - Schematic diagram of an electric vehicle

The main advantages of an electric vehicle: no harmful emissions; simplicity of design (including the traction electric motor) and control; high reliability and durability of the power plant compared to a conventional car; the possibility of recharging from a household electrical network, but this method takes 5... 10 times longer than from a special high-voltage charger;; traction electric motors have an efficiency of 92...98% compared to the efficiency of an internal combustion engine of 20...30%; less noise due to fewer moving parts and mechanical gears; the possibility of recharging energy sources during regenerative braking.

Today, the weight, capacity and recharging time of batteries are still the weakest points of electric vehicles.

In general, the process of driving an electric vehicle in urban mode without having to change the speed due to obstacles encountered on the way (pedestrians, speed limits, road signs, other road users, regulated and unregulated intersections) consists of four stages:

- acceleration and/or speed maintenance, if necessary - a smooth increase in speed to a predetermined value with restrictions on phase coordinates and control;

- acceleration - movement without power supply to the wheels;
- regenerative braking - braking of electric machines operating in generator mode to charge the electric energy storage device;
- braking by the service brake system - braking with mechanical brakes to stop at a given location.

At the stages of acceleration and speed maintenance, the energy stored in on-board power sources is used to achieve or maintain the design speed of the electric vehicle. The energy conversion is as follows.

The electrical energy stored in the batteries (energy storage devices), minus losses in the converter (traction inverter), is used to rotate the rotor of the electric vehicle, being converted into mechanical energy with a coefficient of efficiency (COE) that depends on the frequency of rotation of the electric vehicle shaft and the amount of perceived load.

Further, the mechanical energy of the electric machine rotor rotation is converted into the kinetic energy of the electric bus movement by means of a transmission and a motor. In the transmission, the energy is used to overcome the friction force in the components and bearings, as well as to mix the gear oil of the rear axle. In the propulsion system, energy is consumed by sliding in the contact patch and overcoming rolling resistance.

When the electric bus is braking, part of the energy, excluding losses, can be returned to the storage device. In this case, the energy conversion is reversed. The kinetic energy of the electric bus movement is used to rotate the rotor of the electric motor by means of the motor and transmission, and part of the mechanical energy can be converted into heat and dissipated into the atmosphere by the operating brake mechanisms.

The mechanical energy of the rotor rotation is then converted with losses into electrical energy by an electric machine operating in energy recovery mode. The electrical energy, minus the losses in the converter, is then stored in a battery. Thus, one of the ways to reduce costs and reduce irrecoverable energy losses is to minimise the use of the service brake system.

Energy losses in the converter and transmission must be taken into account using the efficiency of the electric bus components.

The task of an energy-efficient control law for wheeled autonomous urban electric transport between stops on a city route should be formulated as an optimization problem: to determine the law of change in speed from the distance travelled *v(s)* on the route when moving from a route point with phase coordinates S_1, $v_1 = 0$ to a route point S_2, $v_2 = 0$, for time $T = t_2 - t_1$ while minimizing the energy consumed for movement, which is determined by the objective function

$$J = \int_{t_1}^{t_2} \left(N_p - N_T + N_{MT}\right) dt \Rightarrow min \tag{1}$$

where N_p – is the discharge power of the drive developed during acceleration; N_T – is the charging power of the drive during regenerative braking; N_{MT} – is the power consumed when using the service brake system.

Conclusions

A method for determining the energy-efficient law of electric vehicle movement along a city route has been developed, which differs in the use of the dynamic programming method for solving the optimisation problem with respect to an urban transport object.

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