Internal combustion engine as electrical machine

A B Feodorov, V I Afanasov, R S Miroshnikov, K R Maslov, A V Bushkina

Siberian Federal University, 79, Svobodny Ave., Krasnoyarsk, 660041, Russia

E-mail: feodorov@mail.ru

Abstract. The features of the development of power units of power machines are considered. Competition, imposed by the construction of electric vehicles, requires a review of the physical processes occurring in the internal combustion engine (ICE). The combustion gases are a plasma. An important act is the emission of free electrons. It is proposed to consider ICE as an electric machine. The modernization of the structural elements of the combustion chamber is being discussed. They must become sources of free electrons. Thermodynamic processes are considered to be electrodynamic. The goal is the formation of increased concentrations of free electrons. It is proposed to place electron emission catalysts on the inner surfaces of the combustion chamber. Vibrations of the internal elements of the combustion chamber are considered as a source of triboelectricity.

1. Introduction

The automotive engineering industry is massively involved in the creation of an electric vehicle. This movement is caused by a variety of different causes.

On the other hand, today's electric car is a very expensive toy. Its existence on the market became possible only thanks to state financing programs. The production of an electric vehicle is still very far away from securing a profitable business.

The basic arrangement consists of electric motors, batteries and electric generators. The generation of energy, transformation into an electrical form and the use of electricity for the production of traffic are carried out by various units.

Electric generators can use an internal combustion engine (ICE) to generate electricity. And in this case, ICE takes a subordinate position. There are electric vehicles with ICE for generating electricity. Such machines are a sign of the period of hybrids. Cars in the beginning of the history were hybrids too. The competition between ICE and the electric vehicle is long and varied.

Our attention is attracted by an electric hybrid based on ICE. In the working pistons ICE is the process of combustion of gases. A burning gas is a plasma, an essential act in which is the transition of electrons. It should be specially emphasized that the state of the plasma in the working cycle of the piston is due to the action of "free electrons".

ICE in the coming competition has a big temporary head start due to the huge investment infrastructure. It was created to serve ICE for more than 100 years. Therefore, you should carefully look at the prospects of ICE as the basis of an electric hybrid car.

From the point of view of inventive art, the ICE is of interest as an electric machine. The plasma of a burning gas mixture in a working piston is a bright example of electrical processes. An essential element of the latter: the separation of electrons and their functioning as "free agents." A separate study requires processes carried out by "free electrons" in the combustion of gases. And also the processes of energy release in a gas plasma.

2. Electrons initiators of plasma

Researchers of air supply systems in the combustion chamber [1, 2] pay attention to increasing the efficiency of the ICE during a thunderstorm or immediately after it. In such periods, atmospheric air is saturated with ions, as evidenced by the characteristic smell of ozone. Based on these observations and specially performed studies, useful samples [1, 2] of the air ionization device were registered. The device is intended for installation in the air cleaner duct. Preliminary ionization of the air supplied to the combustion chamber leads to an improvement in the performance of the ICE. In the expansion working area, a "uniform plasma" is created throughout the piston volume. Accordingly, chemical reactions are more effective. The exhaust of unburned components is reduced. The environmental characteristics of ICE are improving.

Stormy weather conditions or devices for preliminary ionization of air provide an increase in the concentrations of gas ions. "Free electrons" are of paramount importance for the operation of ICE.

Thus, the direction of modernization of ICE has been outlined. It is necessary to increase the concentration of free electrons in the gas in order to optimize the plasma characteristics.

3. Electron emission in the combustion chamber

Emission of free electrons is made by means of structural elements placed directly in the combustion chamber. Winnings are achieved through impulse processes.

Pulsed emission in the combustion chamber must be co-operable with the processes of energy release of burning gases. The impulsive character of the emission of electrons makes it possible to save the energy of the discharge. Requirements for the characteristics of an external electric discharge are simplified. It is possible to use high-energy fast-flowing processes in atoms, as well as metastable states of ions.

The traditional approach to the creation of an ionized gas is based on ideas of the theory of thermionic emission. The source of ionization, the creation of free electrons are often pairs of alkali metals. For example, cesium Cs [3], as an element with the lowest ionization potential.

The authors of [4-6], point to the practical attainability of high electron current density. When an electric field with a Fe intensity of ~ 3 10^7 V / cm to ~ 10^8 V / cm is applied to the surface of the refractory metal, the theoretical value of the current density of the thermal field emission (JTFE) can vary from ~ 10^4 A / cm^2 to ~ 10^9 A / cm^2.

In [4], the phenomenon of "anomalous ionization" is discussed with the use of microstructures, as a way to solve the technical need for intense sources of electron emission [7-13]. The discrepancies with the predictions of the thermoemission theory are pointed out. An example of such anomalous emission characteristics is zirconium oxide ZrO_2 in the form of nanoparticles. Experimental studies of the ZrO_2 layer on a metal (tungsten) with a thickness of one monolayer and a layer thickness of about 10 nm at T = 2000 ° K are reported. An experimental curve is presented for the dependence of the total emission current on the temperature of the ZrO_2 / W <100> substance at one and the same fixed value of the potential and intensity of the extracting field (Ve = 6000 V, Fe ≈ 1440 V / μm). A monotonic increase in the emission current is demonstrated with an increase in temperature in the range T from 1950 °K to 2150 °K. At maximum, the emission current from the tip of the cathode reaches 0.55 milliamps at a temperature of T = 2150 °K.

Theoretical explanation of the effect of anomalous emission is a matter of the future. Practical use can be effective and will allow obtaining more empirical information for the formulation of model representations.

4. Generation of free electrons

In the works under consideration, for the purpose of increasing the emission of electrons, a combination of thermal heating and an electric field is used.

Triboelectricity is of special interest as a method for generating an electric field. The friction process is easily realized in practice and is always present in moving aggregates. Static electricity is characterized by rather high intensity and low emission currents.

In the presence of friction and vibration, one can expect to obtain the required electric field [14]. Korean engineers have created a triboelectric generator with a flutter-drive, that is, a device that allows you to receive electricity from vibration. Vibrations, in this case, are created with the help of flexible flags made of conductive fabric, attached at one end to a rigid metal plate. The frequency of vibration slightly exceeds 150 hertz. The experimental device showed the possibility of removing current at such a periodicity.

Based on these data, one can count on the generation of an electric field at the frequency of the internal combustion engine. As the frequency of repetition increases, the conditions for maintaining the field strength created by friction are improved.

5. Discussion

The inclusion of electron generators directly into the combustion chamber is a promising direction for the modernization of ICE.

This direction is initially represented by spark plugs [15, 16]. At the end of the compression stroke, the combustible mixture ignites from the electric spark generated between the spark plug electrodes. There is a rapid combustion, as a result of which the temperature of the gases formed increases sharply. The maximum temperature of gases during combustion for carburetor engines is in the range 1800-2200 ° K.

Microparticles have already found application as additives to fuel. Cerium oxide is widely used as a catalyst in three-way converters to eliminate toxic emissions of exhaust gases and reduce the release of particulate matter in cars. The cerium oxide contained in the catalyst can act as a reactive component. It works as an oxygen storage facility with the release of oxygen in the presence of reducing gases and the removal of oxygen when interacting with oxidizing substances.

The patent [17] proposes a method for intensification of combustion using cerium oxide nanoparticles CeO_2 in automotive fuels. Including in combination with zirconium. Combined nanostructures of cerium oxide CeO_2 and zirconium oxide ZrO_2 are studied in detail in catalytic processes [18].

Cerium oxide can store and release lattice oxygen through the following processes [17]:

$$2CeO_2 \leftrightarrow Ce_2O_3 + 1/2O_2.$$

Cerium oxide particles should be nanocrystalline in nature, for example, they should be less than 1 μm in size and preferably 1-300 nm in size.

It is promising to modify the elements of the combustion chamber by introducing ZrO_2 nanoparticles with a size of about 10 nanometers.

Dislocations of ZrO_2 nanoparticles on the surface of the piston and the inner surface of the cylinder create conditions for the generation of triboelectricity (Fig. 1).

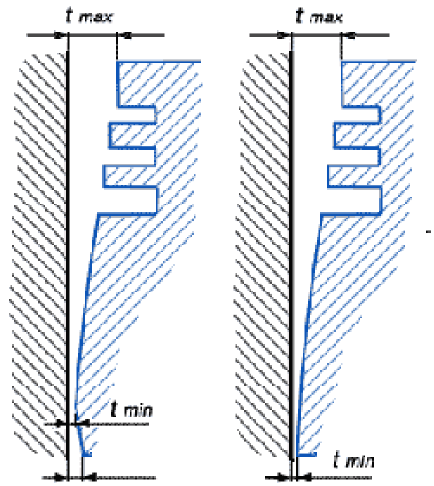

Figure 1. Conditions of friction and vibration of the piston in the cylinder.

Electrification during metal oxide friction can generate local electric fields. In combination with the temperature growing at ignition; conditions for intense electron emission are formed. Electrons emitted by particles of zirconium oxide ZrO_2 activate the combustion process. A system with positive feedback is formed. The choice of design parameters maximizes the use of the gas mixture.

6. Conclusion

The problem of reducing the temperature of the anomalous growth of electron emission [18] deserves attention. There are two areas of research. This is the aforementioned prospect of a combination of zirconium oxides ZrO2 and cerium CeO2 for the purpose of combining their advantages in the works of N.V. Zaletova [18]. A separate interest is a deeper study of the kinetics of phase transitions between different states of the crystal symmetry of zirconium oxide ZrO2. This direction already attracts the efforts of researchers [19].

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