

ANNOTATION

of Dissertations for the degree of Doctor of Philosophy PhD
in the field of preparation: 8D071 – «Engineering and Engineering»,
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KRYUCHKOV YEVGENIY

THEORETICAL AND EXPERIMENTAL SUBSTANTIATION OF THE DESIGN AND METHOD OF OPERATION OF AN ELECTRIC IMPULSE AUTOMOBILE MUFFLER

Relevance of the dissertation work. In the modern world, road transport plays an important role in human daily life. However, it is also one of the main sources of environmental pollution, especially in large cities. Emissions of harmful substances into the atmosphere lead to deterioration of air quality, human health and climate change.

In this regard, in recent years, the world community has been actively working to reduce harmful emissions from vehicles and increase their environmental safety. This is achieved in various ways: introducing new technologies, improving fuel quality, increasing requirements for environmental standards, etc.

Improving the sustainability of road transport is critical for air quality, with the global vehicle fleet expected to triple by 2050 and greenhouse gas emissions from the transport sector growing faster than others.

Air pollution causes seven million premature deaths each year, mostly in developing countries, and is associated with increased susceptibility to COVID-19.

One of the directions in reducing emissions of harmful substances, along with others, is the use of electric pulse silencers in road transport. This is a new and promising direction that can significantly reduce harmful emissions and improve the environmental parameters of the car.

The development of new and improvement of existing exhaust gas purification systems is an important area for reducing the impact of road transport on the environment.

There are a significant number of designs of electrostatic precipitators and studies of processes for purifying gases with electric discharges. However, there are no well-developed theoretical and experimental studies of the operation of gas by an electric pulse muffler built into its body. In this regard, research aimed at creating an electric pulse muffler is **relevant**.

The hypothesis of the study is the assumption that it is possible to effectively clean car exhaust gases directly in the muffler using a corona electric discharge.

The purpose of the study is to obtain experimental and theoretical dependencies describing the mode and design of an electric pulse muffler.

To achieve the goal, the following **tasks were solved** :

- an analysis of possible designs of automobile mufflers and methods of exhaust gas purification was carried out;
- research on electric pulse purification of exhaust gases was analyzed;
- the physical essence of gas purification in the proposed design is described;
- 2 experimental full-size stands were developed;
- experimental relationships have been established linking the distance between the electrodes, the electric field voltage, the engine crankshaft speed, the dynamic viscosity of the gas with smoke and oxygen content;
- a mathematical model was developed and studied, a comparison of analytical and experimental results was made;
- an experimental sample of an electric pulse muffler was manufactured;
- technical specifications for the design of an electric pulse muffler were developed.

Research methods. The dissertation uses methods of mathematical statistics, mathematical analysis, planning and processing of experiments.

The scientific novelty of the study is as follows:

with an electric pulse was experimentally proven ; after its exposure, the oxygen content increased and the smoke (for diesel engines) decreased;

- the effectiveness of using corona discharge for gas purification by regulating the distance between the electrodes and the electric field strength has been proven;

- dependencies were obtained analytically and experimentally confirmed, connecting the distance between the electrodes, the electric field strength, the engine crankshaft speed, the capacity of the combustion chambers, the muffler radius and the dynamic viscosity of the gas;

- experimental dependencies were obtained relating the engine speed and the percentage of oxygen, carbon dioxide and carbon monoxide before and after exposure to a corona discharge. The oxygen content increases after exposure.

- relationships were established between the ratio of oxygen and other gases before and after cleaning with the distance between the electrodes. The optimal distances between the electrodes for an engine speed of 700 rpm is 2 mm, for 1400 rpm – 6 mm, 1900 rpm – 4 mm.

similarity criteria were obtained that determine the ratio of active to passive forces and the ratio of gas flow rates in the engine and muffler. One of the similarity criteria is an analogue of the Reynolds criterion;

- as follows from the obtained dependencies, the opacity of the exhaust gases of a diesel engine after exposure to a corona discharge decreased, and the oxygen content increased;

Scientific provisions submitted for defense:

- under the influence of a corona discharge, the oxygen content in the exhaust gas increases and its opacity decreases;

- regulation of the cleaning process depends on the distance between the electrodes and the electric field strength;

- the optimal distance between the electrodes is inversely proportional to the engine crankshaft speed, the total capacity of the combustion chambers and the dynamic viscosity of the gas and directly proportional to the electric field strength and the size of the middle section of the muffler;

- similarity criteria determine the necessary conditions for the gas purification process and the dimensions of the muffler.

The author defends:

- stand designs;

- obtained experimental and theoretical results;

- mathematical model and results of its research;

- technical specifications and basic calculation dependencies.

The object of the study is an electric pulse automobile muffler designed to purify exhaust gases.

The subject of the study is the process of reducing the toxicity of exhaust gases due to the occurrence of a gas discharge inside the muffler.

The practical significance lies in obtaining the main calculated dependencies that describe the mode and design of the electric pulse muffler.

The research results were transferred to INSTITUTE GRADIENT PROJECT LLP.

Summary. In the first chapter of the dissertation, an analysis of existing methods for purifying harmful and toxic gases and the designs of automobile mufflers was carried out. A review of patent design solutions used in the exhaust system of a car has been completed. The rationale for the need for electric pulse purification of exhaust gases is given. The goals and objectives of the study are set.

The second chapter describes the physical essence of the cleaning process. The goals and objectives of the experiment are set. Experimental stands and measuring equipment are described. The methodology and experimental plans are presented. An analysis of the obtained results was carried out.

The third chapter of the dissertation is devoted to mathematical modeling of the process of operation of an electric pulse muffler. A mathematical model of the motion of a gas particle has been developed and studied. Similarity criteria for electric pulse mufflers and optimal distances between electrodes at different engine crankshaft speeds have been established. A comparison of theoretical and experimental results of the study is given.

The fourth chapter shows the design of the prototype and technical specifications. A methodology for calculating the main parameters of the operation of an electric pulse muffler is given. A calculation of economic efficiency was carried out.

Personal contribution of the dissertation candidate.

The author personally carried out the research, including an analysis of methods for cleaning exhaust gases from internal combustion engines in cars. A comparative analysis of the designs of automobile mufflers was also carried out. Participated in the development and research of a mathematical model of the operation of an electric pulse automobile muffler. Three experimental automobile

mufflers were created to confirm the results obtained analytically. Analytical and experimental dependencies describing the operation of an electric pulse automobile muffler were obtained and compared.

Publication and testing of the work. The main provisions of the dissertation were published in one article included in the Scopus database , four articles recommended by the Committee for Quality Assurance in Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan, in one patent for a utility model of the Republic of Kazakhstan, and in three theses on international scientific and practical conferences.

In the article «Studying the process of the internal combustion engine exhausted gas purification by an electric pulse» in the magazine «KOMUNIKACIE» included in the Scopus database , 3rd quartile, percentile for Transport 43, in the section of the magazine «Automotivein Transport», <https://doi.org/10.26552/com.C.2022.4.B275-B287> the author developed an experimental electric pulse automobile muffler, conducted an experimental study and obtained positive results on the purification of exhaust gas from internal combustion engines of cars using an electric pulse . In the article «Автокөліктің пайдаланылған газдарын электр импульсті бейтараптандыру процесін зерттеуге арналған эксперименттік қондырғыларды әзірлеу» in the journal "Proceedings of the University" of Abylkas Saginov KarTU, section «Construction. Transport» the author presented an analysis of well-known patents in this direction, described the developed experimental stands for determining the neutralization mode (voltage, duty cycle, distance between electrodes). In the article «Experimental determination on cleaning the exhausted gas of an automobile muffler by an electric pulse» in the journal «Bulletin of the L.N. Gumilyov Eurasian National University», series Technical Sciences and Technologies, the author conducted an experimental study and obtained data on changes in exhaust gas opacity indicators depending on changes in the distances between the electrodes. Thus, empirical dependences of the values were established p transparency and gas from changes in the distances between the electrodes based on the regression-correlation analysis. In the article «Establishment of Parameters of Electric Pulse Equipment Storage Device for Exhaust Gas Purification» in the journal «Proceedings of the University» of KarTU, section «Construction.Transport» he described the physics of the process of electric pulse purification of exhaust gases. The dependences of the illumination of the purified gas on the time of exposure to the electric pulse, the frequency of the electric pulse and the distance between the electrodes were obtained. In the article «Study of the process of electric pulse cleaning of internal combustion engine exhaust gases» in the magazine «Bulletin of KazATK», section «Transport, transport engineering» the author described the general design of an electric pulse cleaning stand with movable electrodes, as well as the principle of its operation. Conducted an analysis of the experimental results and determined the optimal operating modes of the electric pulse equipment of the designed internal combustion engine exhaust gas purification systems.

Structure and scope of the dissertation. The dissertation work is presented on 119 pages of typewritten text, consists of symbols and abbreviations, introduction, 4 sections and conclusion, includes 73 figures, 30 tables, a list of used sources from 117 titles and 3 appendices.

Research results and main conclusions.

The dissertation contains new, scientifically based results that provide a solution to the important practical problem of developing a methodology for calculating the design parameters of an electric pulse automobile muffler. Based on the results of the study, the following conclusions were drawn:

- and the analysis of research on electric pulse purification of exhaust gases and car muffler designs made it possible to substantiate the purpose and objectives of the study;

- a physical picture of the purification of exhaust gases by an electric discharge has been written, and the effectiveness of using a corona discharge has been substantiated;

- two experimental stands were developed, the methodology and procedure for the research experiment were developed;

- the hypothesis about the possible effective purification of exhaust gases in a car muffler equipped with an electric pulse device was confirmed;

- and analysis of experimental studies showed an increase in the percentage of oxygen and a decrease in smoke after exposure to an electric pulse ;

- a mathematical model was developed and studied and for the first time a dependence was obtained connecting the engine speed, the capacity of the combustion chambers, the distance between the electrodes, the dynamic viscosity of the gas and the radius of the exhaust gas atoms;

- the possibility of optimizing the cleaning mode by changing the distance between the electrodes was substantiated and its optimal values were established for different engine speeds;

- under the influence of a high voltage electric field, a process of plasma dissociation occurs, in which molecules of carbon dioxide and carbon monoxide decompose into individual carbon and oxygen atoms. These atoms further participate in chemical reactions with other molecules;

- technical specifications for the production of a pilot design of an electric pulse automobile muffler have been developed;

- based on the technical specifications, a prototype of an electric pulse automobile muffler was manufactured.