ABSTRACT

to the thesis research, submitted for the PhD degree in the
educational program «8D07101 – Renewable Energy»
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by
ANUARBEKOV MAXAT

«Development of a burner device for burning
synthetic gases (biogas) based on swirling flows»

Renewable energy sources (RES) are the most relevant topic in the modern world. In particular, for Kazakhstan, it is the production of biogas from the plant and animal world and the use of biogas to generate heat during combustion for various needs of farms. Therefore, biogas are a composition of various gases and where the content of methane CH_4 is much lower compared to natural gas, since they are low reactive and the composition is constantly changing depending on the operating mode of the gas generator. The operation of the gas generator depends on the addition of enzymes and the temperature of the biomass. In order to burn different compositions of biogas obtained from gas generators, it is necessary to create universal burner devices that could effectively burn synthetic or biogas of different compositions. The analysis of various burner devices has shown that the most suitable and acceptable burners are when using microfakel combustion, with different twists, with different return flows, in addition, it is necessary to achieve a circulation effect. According to the results of the literature review, for ignition in the hot zone of biogas and synthetic gas, it is necessary to maintain as much volume of these gases as possible. Also, the ignition temperature will be much higher than that of methane. Therefore, it is necessary to conduct comprehensive studies on the masses of hot gases and on sustainable gorenje and choose the best option rationally.

Relevance of the research. Renewable energy sources, including the use of biogas, are relevant for Kazakhstan. Individual agricultural farms are increasingly in need of universal burner devices in which synthetic gases of different compositions could be burned efficiently. This is possible in microfakel burners with a change in the degree of twist of the air flow.

The object of the study is a microfakel burner with different angle stabilizers, which relate to the microfakel method of burning synthetic gases, biogas based on swirling streams.

Materials and methods of the research: Materials for the manufacture of the burner are stainless steel; research methods: theoretical using modern software packages Ansys fluent and COMSOL Multiphysics; experimental study with an assessment of measurement errors.

The purpose of the dissertation is to develop a new microfakel burner for burning synthetic gases, biogas and research physical and mathematical models, describing processes in swirling streams to reduce experiments.

To achieve this goal, the following research objectives were set:

- Based on the analysis of the microfakel burner designs and patent searches, to develop a new efficient low-toxic biogas burner;
- To study the theory of describing processes in swirling flows on ANSYS fluent to reduce experiments, calculate effective sizes and their ratio;
- to identify the degree of twist of the flow, the formation of toxic substances, the characteristics of the burner at different degrees of twist;
- To develop drawings of the burner parts and organize its manufacture;
- To conduct a comprehensive experimental study of the burner on the stand;
- To compare the experimental and calculated characteristics of the burner and develop recommendations for their operation.

The scientific novelty of the work is as follows:

- A new microfakel burner device for efficient combustion of synthetic gases and biogas has been developed and implemented in the design (3 patents for the invention have been obtained);
- The results of theoretical studies using the Ansys Fluent, Comsol Multiphysics software packages and the choice of geometric dimensions and shapes of microfakel burner device (MFBD) stabilizers.

The results of experimental studies of the characteristics of the MFBD, which determine the perfection of the design, efficiency and quality of the burner when burning various gases.

The practical significance of the dissertation work lies in the fact that:

- the developed and researched burner can be used in various fuel-burning devices, where biogas will be used as fuel;
- the obtained research results will be useful for the creation of low-toxic combustion chambers, heat generators and hot water boilers;
- the materials of the dissertation and the textbook «Агроөнеркәсіпте биоотынды алу және пайдалану негіздері» can be used in the discipline «Renewable energy sources».

Reliability of the work. The reliability of the results obtained in the dissertation work was ensured:

- using Testo 350 gas analyzers with high measurement accuracy in experiments, a fuel consumption meter, a thermoanemometer for measuring the velocity and temperature of exhaust gases, etc.;
- a comparative analysis of theoretical and experimental studies, as well as an analysis of the combustion of synthetic gases and biogas by foreign authors;
- performing an assessment of measurement errors in all parameters;

The provisions submitted for defense:

- The results of theoretical and experimental data on the efficient combustion of synthetic gases, biogas in MFBD;

- The results of the development of a new MFBD with improved basic characteristics that determine the perfection of the design in terms of economic and environmental indicators;

- New designs of burners for burning biogas, synthetic gases, confirmed by patents for inventions.

Publications. On this topic, the dissertation was published: 3 articles in the journal included in the Web of Science database, 3 articles in journals recommended by the SHEQAC, as well as 3 patents for inventions in the Republic of Kazakhstan, 7 reports in collections of international and foreign conferences (Appendix D).

The author's personal contribution consists of: in conducting a literary review and patent search on the topic of the dissertation, performing theoretical research in the Ansys Fluent and Comsol Multiphysics software complexes, conducting experiments, processing experimental data results, publishing articles in scientific and technical journals, obtaining patents for inventions, testing research results. With the participation of a scientific and foreign consultant, the main areas of work were identified.

Volume and structure. The contents of the dissertation work: introduction, sections of 4 chapters, conclusion, list of references and appendices. The volume of the dissertation contains 122 pages, of which 90 figures and 23 tables.

The introduction contains the identified problems on the subject of the study and the relevance of the chosen topic. The statement of the purpose and objectives of the study, the scientific novelty of the work, reliability, personal contribution of the author, articles and approbation of the research results are presented.

The first section provides an overview of key aspects of the features of swirling jets in burner devices, the problems of burning biogas fuels, in particular, the prospects for the development of vortex burner devices TSU. An overview of burner devices for fuel-burning devices, the principle of combustion of which is microfakel combustion, is provided. The advantages and disadvantages of this gorenje are given. The statement of the task and the purpose of the work are defined.

The second section provides a description of the test bench and the physical model itself for the experimental study of burners based on microfakel combustion of swirling streams. The method of conducting experiments, the description and characteristics of measuring instruments, the basic equations for calculating the desired parameters are substantiated, and an estimate of measurement errors is given.

The third section presents the results of mathematical modeling of combustion processes in the Ansys program for the burner under study and determines the formation of harmful toxic emissions. To study the benefits of microfiber device using Comsol and Ansys fluent, an effective stabilizer for stable combustion was selected. Based on the theoretical studies conducted, the influence of the degree of flow swirl and the formation of toxic substances was investigated during the modeling process, and the burner characteristics were determined at different degrees of swirl.

The fourth section presents the results of experimental studies of combustion processes, the efficiency of combustion of biogas and synthetic fuels on an

experimental stand. The results of experimental studies on the selection of an effective design model for a new burner are presented. The results of comparing experimental and calculated parameters of burner models are presented. New technical solutions are described, according to which the author obtained patents for inventions, as well as an analysis of innovative burner devices based on the patents obtained.

The conclusion includes detailed results and conclusions that indicate a high level of research and significance for fuel burning devices.