

ABSTRACT

of the dissertation of Zhalmagambetova Ultuar Kairbolatovna "Technology of providing different types of energy for isolated settlements (at reasonable costs)", presented for the degree of Doctor of Philosophy (PhD) in the specialty 6D071700 - Heat Power Engineering

Relevance of the dissertation research topic. Several thousand villages of Kazakhstan with relatively small populations are currently provided with various types of energy and various technologies. In particular:

- heating and hot water supply is carried out by burning coal in individual furnaces;

- cooking is carried out with gas from cylinders and particularly on individual coal stoves;

- electrical energy is delivered via low-voltage networks.

Each of these supply routes has its drawbacks such as:

- the use of individual stoves, for all its familiarity, requires constant maintenance, including the use of firewood for kindling stoves, increased heat losses due to mechanical underburning (fall through the grate and unburned particles in the ash) and noticeable environmental pollution (ash and flue gases) are observed;

- the use of liquefied gas in cylinders for cooking is characterized by increased dependence on suppliers and relatively high cost;

- the supply of electricity does not meet the reliability requirements (due to the obsolescence of networks and the high cost of updating them).

In Kazakhstan, the supply of coal is at the required level and is delivered at an acceptable cost. However, as already noted, in small settlements, coal is still used only in individual furnaces as a solid fuel. In relatively large settlements, there are cases of generating heat energy from a local source for heating and less often for hot water supply. Generation of electric energy on a local source with low productivity is practically not found.

The dissertation examines the possibility and ways of using coal for generation from a single local source: thermal energy, as well as gaseous fuel for generating electric energy (gas-piston units and/or gas turbines) and cooking in small towns.

The incomplete extraction of volatiles from coal and their further use as gas-like fuel for the production of electric energy and for cooking is relatively new.

It can be immediately noted that the proposed scheme for the production of heat and electricity uses induction boilers and units for generating electric energy. A certain feature can be considered that in the dissertation work, the option of using a hot-water boiler with the installation of a gas unit for generating electric energy is considered.

In addition, the thesis takes into account that the extraction of volatiles for these purposes is somewhat different from the usual pyrolysis, since in this case it is quite sufficient to extract a certain gaseous part of coal. The features of this process for the purpose of generating electric energy and for cooking become necessary for the accelerated accumulation of the required volume of gaseous substance. It is also

obvious that the intensity of extraction of the gaseous part of coal may differ markedly for the coals of different deposits, which may be supplied to different regions of the country. It should also be noted that the coal from which some of the volatiles are extracted remains quite suitable for burning in a conventional layer furnace for generating thermal energy.

The purpose of the dissertation: research and development of producing gaseous fuel technology for gas and power supply of a remote settlement with the use of coal from Kazakhstan deposits.

In connection with the above, the following tasks are set:

- to determine the rational conditions of heating coal for extracting combustible volatiles, including taking into account the possibility of their accumulation in the amount required for further use;

- to experimentally obtain the heat of combustion of combustible gas obtained from coals of various deposits, depending on the parameters of the extraction process;

- determine the composition and intensity of volatile substances release for coals of several Kazakhstan deposits, depending on the temperature, speed and duration of heating with different granulometric composition in the treated layer;

- to develop a mathematical model of the influence of the parameters of the coal heating process on the amount of gas produced;

- to develop a technological scheme for centralized combined production of various types of energy for the power supply of remote small settlements;

- to evaluate the economic feasibility of the proposed scheme for supplying small settlements with various types of energy.

The object of the dissertation work research: coals and their physical and chemical properties, the process of thermal processing of coals from Kazakhstan deposits in order to obtain gaseous fuel.

The subject of research in the dissertation: the laws of thermal transformations on the qualitative and quantitative composition of the resulting gas in the process of heating coal from various factors, as well as the mechanism of using this gas in the production of heat and electricity.

The methodological base is founded on: the provisions of thermal physics and heat power engineering, as well as experimental and theoretical data in the field of research and processing of coal. Materials from international conferences, scientific articles, reference data, statistics, and data from our own experiments were used as information sources.

Scientific provisions submitted for dissertation:

- rational conditions of heating coal for the extraction of combustible volatiles, including the possibility of their accumulation in the amount required for the further use;

- experimental data on the heat of combustion for combustible volatile substances obtained by heating coal of various deposits, depending on the parameters of the extraction process;

- volumes of volatile substances output for coals of several Kazakhstan deposits depending on: temperature, speed and duration of heating with different granulometric composition and layer thickness;
- mathematical model describing the influence of the coal heating process parameters depending from the amount of gas produced with a calorific value not higher than 12 MJ/m³;
- technological scheme of centralized combined production of various types of energy for power supply of remote small settlements;
- construction of a power generating plant for gas generation and power supply.

Scientific novelty of the work:

- the rational conditions for extraction of combustible volatiles are determined;
- the experimental data on the effect of temperature, granulometric composition, heating rate and duration of exposure of the pyrolysis process of Kazakhstan coals on the yield, intensity of volatile substances release and their heat of combustion were obtained;
- the mathematical model of the parameters of the coal heating process influence on the amount of gas produced with a calorific value of no more than 12 MJ/m³ was developed;
- the technological scheme of the power generating plant of gas, heat and electricity was developed;
- the technology was developed and protected by the patent for an Autonomous source of combined production of various types of energy for power supply of remote small settlements. (PM KZ No. 4356 of 13.05.2019).

Practical value. The developed technology makes it possible to provide remote settlements with a relatively small number of inhabitants with most types of energy consumed at an acceptable cost.

The practical value is confirmed by the acts of research work implementation results in the industry: «Проектцентр» LLP, «Нефтехим LTD» LLP.

Approbation of research results:

- 7th International Conference on Thermal Equipment, Renewable Energy and Rural Development;
- II international scientific and practical conference of students and young scientists "Modern trends in boiler construction" of AISTU, 2018;
- IV All-Russian scientific and practical conference, Energy and energy saving: theory and practice", 2019.

Publications: published one article related to the topic of the dissertation in a journal included in the Scopus database, one article in a journal included in the Web of Science database, two articles in journals recommended by KOKCOH; 4 articles in foreign collections of international conferences materials, also 1 utility model patent, one patent pending have been received.

The author's personal contribution consists of preparing a plan for experimental research, developing research methods, setting up, preparing and conducting experiments, obtaining and processing experimental data at all stages of work, testing the results of work, preparing texts of articles for publication in scientific journals and

conference collections, and preparing patents. The scientific idea, direction and tasks of research were formulated with the participation of the scientific supervisor. An Autonomous source of combined production of various types of energy for power supply of remote small settlements has been developed and protected by a patent.

The reliability of the results is ensured by the use of modern means and methods of research; the use of modern, calibrated and verified recording and testing equipment that allows to measure the required parameters with high accuracy; adaptation of experimental data simulation results with high accuracy; consistency with other authors' research.

The structure and scope of the thesis. The thesis consists of content, introduction, four chapters, conclusion and three applications. The work is presented on 98 pages including 47 figures and 18 tables. The bibliographic list includes 73 titles.

In the introduction, the relevance of the topic is justified, the purpose and objectives of the work are formulated, the scientific novelty, the practical significance of the results obtained and the main provisions submitted for dissertation are noted.

Chapter 1 is devoted to the analysis of energy supply in remote settlements with no centralized heat supply, and in some cases the electricity supply is made from individual sources running on expensive liquid and gaseous fuels. At the same time, in the Northern regions of Kazakhstan, coal is the only available source of energy which is used for the furnace heating is ineffective when burned in a layer. Given the climatic conditions, geographical location and location of the country's fuel resources, decentralized energy supply is preferable, particularly for dispersed localities where coal is the only available fuel.

Chapter 2 is devoted to the study of the physical and chemical properties of coal from Kazakhstan's deposits. Various research methods were used to determine the quality indicators of coals. The method was chosen from the point of view of rational use of coal in its thermal processing, in order to obtain a gaseous fuel. At the first stage of the experimental part, the minimum temperature range was determined during heat treatment with the release of gaseous substances with the necessary calorific characteristics. The solution to this problem was to determine the yield of gaseous products when heating coal in the temperature range from 300 to 600 °C with an interval of 100 °C. In this case, it is an indicator that reflects the chemical nature and is used to evaluate coal as a raw material for technological processing. At the next stage, the processes of thermal transformations of coals in oxidizing environment (in air) and in inert environment (in a helium flow) media from the Ekibastuz, Maikuben and Karazhyra deposits were studied by derivatography. The third stage of experiments is devoted to the study of the thermal stability of coals. The gas composition was determined by heating coal from the Karazhyra, Maikuben and Ekibastuz deposits to a temperature of 500 °C for 20 and 40 minutes and 60 minutes.

Chapter 3 is devoted to modeling the heating process of coal from the Maikuben and Karazhyra deposits. When processing the experimental data, regression analysis was used as a mathematical apparatus. The purpose of the simulation is to determine the dependence of the volume of volatiles release on three different factors. As a result, dependences were obtained, according to which the size of the fraction has a significant

effect on the gas yield, the heating rate has a less significant effect, and the mass of coal has practically no effect.

Chapter 4 is devoted to the development of technology for providing energy of various types to the village remote from the centralized power supply. A variant of autonomous power supply has been proposed, involving a transition to a single-fuel system, which is an advantage in regions where coal is the only source of energy, excluding the use of hydrocarbon gas and liquid fuel. A diagram of a power generating plant for the production of gas, heat and electric energy, as well as a technological diagram of an autonomous combined heat and power supply have been developed.

According to the economic calculations, the costs are 179 424 660 tenge, while the prime cost will be 20,13 tenge per kW / h, which is 4,22 tenge lower than with traditional power supply in the villages. The payback period is 4.5 years.

Main results:

- the physico-chemical properties of coal deposits in the Sary-Adyr, Shubarkol karagara, Maikuben and Ekibastuz. a comparative analysis was carried out, according to which it is possible to determine the rational holding time for all types of test samples at a temperature of 500 °C - 40 minutes, since the gas released under these experimental conditions already has sufficient heat of combustion (12 MJ/m³);

- as a result of the experiment, the average values of the output of gas components (hydrogen, carbon monoxide, methane) were obtained for coal from the karazhyr, Maikuben and Ekibastuz deposits, with different holding times at a temperature of 500 °C. according to the comparative analysis, the maximum H₂ content, about 70 %, is obtained by heating 40, 60 minutes of coal from the Ekibastuz and Maikuben deposits. The largest methane yield by heating 40 minutes and more coal Karazhyra -14 %;

- the maximum amount of gas output in relation to the initial mass, about 36,25 % is obtained when heating the coal of the karazhyr field, warming up for 40 minutes, the minimum when heating the coal of the Ekibastuz field (less than 10 %);

- the largest amount of gas was obtained at a temperature of 600 °C – 18,7 %, which corresponds to a gas calorific value of about 15,79 MJ. when testing coal from the Shuborkolskoye field. The lowest yield of volatiles when heating coal from the Sary-Adyr Deposit is 6,7 %;

- with a sufficient degree of accuracy for engineering calculations the dependence of the gas outlet from the particle size and the rate of heating of coal deposits Maikuben and karagara, according to mathematical modeling, a significant effect on the exit gas, which has a particle size less significantly affected by the heating rate, and almost not influenced by the mass of coal;

- developed and patented an Autonomous source of gas and power supply, which is based on a scheme for supplying gas, heat and electricity to a remote locality (PM KZ No. 4356 of 13.05.2019);

- the technological scheme of centralized combined production of various types of energy for power supply of remote small settlements has been developed;

- the scheme of the power generating plant for gas, heat and electricity generation has been developed.