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OPTIMIZATION OF HEAT SUPPLY AND WATER SUPPLY SYSTEMS FOR REMOTE RURAL REGIONS

The problems of providing various types of energy to remote isolated settlements, territorial and climatic features consideration are reviewed, a three – pipe water supply system, a technology working on solid fuel for heat and electricity supply adapted to the conditions of a particular village are proposed.

The use of the proposed methods of supply will reduce the cost of electricity, heat, water and gaseous fuel. Which will be quite acceptable for families with medium and small incomes. The described technology for producing gas with an acceptable calorific value is based on partial heat treatment of coal. The presence of gaseous fuel allows you to transfer cooking to the supply of fuel from a single.

Keywords: energy supply, power supply, water supply, heat supply, gas supply.

Introduction

Currently, in Kazakhstan, as in Russia, the supply of heat energy and cooking is made by individual stoves on solid fuel with increased financial and labor costs (fuel procurement for the entire season, fuel preparation for combustion, etc.), the supply of electric energy is made by individual sources on liquid fuel (with a high cost), and in water supply systems, water with the same quality is used through a single pipe, despite a noticeable difference in the direction of use.

Numerous remote villages do not have access to a common supply system for various types of energy. Some territories are characterized by cold climatic conditions and a long heating period. The construction of systems for providing various types of energy to remote settlements is complicated by high costs, and the delivery of goods, including fuel, especially liquid, is not always cost-effective [1]. (especially relative losses that are directly related to the amount of energy transported) were very high [2, 3].

The lack of energy and its high cost limit the possibilities of providing comfortable living and is the main factor constraining economic growth in such regions [3].

In the world practice, there is a successful experience of increasing energy efficiency and developing renewable energy sources. After all, usually the increase in the efficiency of electricity supply to isolated consumers is made through the use of renewable energy sources (RES). But with such methods, it is necessary to take into account the climatic conditions and the economic feasibility of using renewable energy sources.

In everyday life water of different quality is required for consumption. The first type is drinking water, the quality of which should be subject to the most stringent requirements. Currently, many residents use either bottled water (very expensive-up to 40 thousand tenge per ton) or additional filters are installed on the taps. Water with this quality will be used for cooking and drinking. The second type is water used for sanitary and hygienic needs (washing dishes, cleaning, washing, showering, etc.) that is the water supplied by the current water supply system. In most cities and in a significant part of rural localities this system is used. Water with this quality, unfortunately, is also used where this quality is not required at all – in toilets. We can assume that this is a legacy of the inertia of previous years. At the same time, the water consumption in the toilet (the third type of water) accounts for the largest share in the areas of water use listed earlier. For example, each family member consumes about 3-5 liters of water per day for food and drink needs.

The consumption of water for sanitary and hygienic needs per inhabitant is approximately at the level of 10-20 liters. The average daily consumption in the toilet of a family of 4 people is an average of 160 liters, or about 60,000 liters of purified water, which is supposed to be drinkable, is flushed into the toilet bowl per year. These figures are undoubtedly a reason for reflection and search for solutions.

Materials and methods

For heat and electricity supply, it is more economically feasible to use coal as the main fuel, especially for settlements located near deposits. Consider the technology adapted to the conditions of a particular village. The technology under consideration runs on solid fuel and provides for:

- supply of heat energy for heating and for hot water needs;
- supply of gaseous fuel for cooking;
- supply of electrical energy.

It is known that it is possible to obtain a gaseous fuel from a solid fuel. This is the extraction of gaseous, so-called combustible volatiles, with an acceptable heat of combustion (from coal and firewood). The presence of gaseous fuel allows you to transfer cooking to the supply of fuel from a single source (for a given village). The resulting gaseous fuel also makes it possible to obtain electrical energy using gas turbines of a special design (with reduced blade wear).

The proposed technology may look like this. In the village (if there is a sufficient amount of solid fuel), a generator of volatile substances (from coal or firewood (previously dried in a special device) is installed. The resulting combustible volatile substances accumulate in a special receiver or are fed to the local gas network (for cooking). Volatiles from the receiver are also fed into the combustion chamber of the gas turbine, which serves as a drive to the electric generator. This allows you to separate the production of electrical and thermal energy and use volatile substances, mainly for generating electrical energy and cooking. The residual heat (after the gas turbines) is sent to the furnace space to generate thermal energy (mainly for the supply of hot water (via its local network). Coal, from which a certain amount of volatile substances is extracted, is fed to another boiler, where it is burned (as in a layer furnace) to produce thermal energy (for heating). Expert assessment shows that with this separation of coal (firewood) burning, emissions of gaseous pollutants (especially nitrogen oxides and sulfur) into the atmosphere are significantly reduced. Thermal energy for heating is supplied to each house via the local heat network.

The block diagram of the proposed technology is shown in fig 1.

Wind energy can be used to power the pump. The development of a new direction in the development of new technologies for providing isolated remote settlements with electric and thermal energy (for heating and hot water) is provided in the scheme.

Such a method of autonomous supply of various types of energy involves the development of technology and design of a generator for obtaining volatile substances from coal or firewood in the required amount, as well as a receiver of the necessary capacity for storing gaseous fuel. The main element of the new energy supply technology for a small settlement will be a gas turbine (with a reduced cost), capable of operating on non-purified volatile substances, with increased suitability for replacing the blades and possibly repairing the combustion chamber. A gas turbine of this design will operate with lower energy efficiency in the production of electrical energy (however, the total energy use of the fuel will not change because the residual heat will be converted into thermal energy in the boiler).

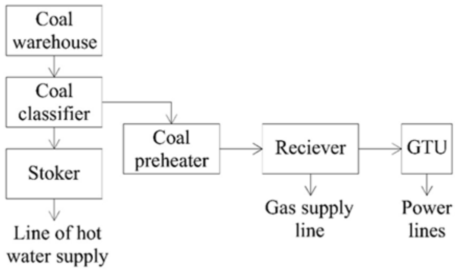

Figure 1 – Technology for providing an isolated village with various types of energy

The installation of metering devices significantly reduced water consumption. It can be noted that reduction of water consumption on toilet bowls have been developed. However, a more complete option to reduce the consumption of «potable» delivered through the water supply system water, while maintaining the required level of supply, can be the transition to a three-pipe supply of water of different quality.

In the most general case, the proposed scheme may be as follows. For sanitary and hygienic needs, the existing water supply system is used.

For cooking and drinking, a common filter is installed for the entire house (in apartment buildings) or for several houses or for a house (in cottages or single-story houses). Water with this degree of purification is supplied through its pipe system and its quality is strictly controlled. Obviously, it will be relatively expensive water, which will be an effective incentive for economical use.

For toilets, you can use ground water of any quality, extracted from a well, installed for several houses. This scheme can be considered the most effective system for saving drinking water quality.

Earlier, we conducted dissertation research in the field of providing various types of energy to an isolated village at an acceptable cost. Water supply plays a special role in these studies, since water itself is used not only as a heat carrier,but also for household needs and cooking. For the considered isolated object, the water supply system is a complex of structures for providing a group of consumers with water in the required quantities and the required quality. In addition, the water supply system must have a certain degree of reliability, that is, to ensure the supply of water to consumers without an unacceptable reduction in the established performance indicators in relation to the quantity or quality of the supplied water. The main requirement is that there is no interruption or reduction in the water supply or deterioration of its quality within unacceptable limits.

Results and discussion

Preliminary experiments (fig. 2) for coal from the Maikubenskoye field, located in Kazakhstan, suggest that the minimum heating temperature of coal to obtain the required concentration of combustible components is 500 °C.

The composition and total yield of the combustible components of gas and brown coal from the Maikubenskoye field are investigated.

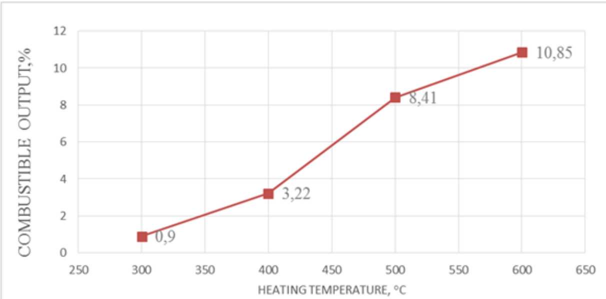

Figure 2 – Dependence of the gas output when heating the coal of the Maikubenskoye field in the temperature range from 300-600 °C

The water supply system of an isolated village must provide water from natural sources, its purification, if this is caused by the requirements of consumers, and supply to the places of consumption. To perform these tasks, the following structures that are part of the water supply system are used:

- water intake facilities, with the help of which water is received from natural sources;
- water-lifting structures, i.e. pumping stations that supply water to places of its purification, storage and consumption;
- water treatment facilities;
- water pipes and water supply networks used for transporting and supplying water to its storage sites;
- towers and reservoirs that act as regulating and spare tanks in the water supply system.

Fig 3 demonstrates the traditional scheme, water from natural sources is taken by means of a water intake structure 1 and is fed by pumps installed at the pumping station of the first lift 2a to the treatment facilities 3. After treatment, the water is fed to the collection tank 4, from which it is taken by another group of pumps installed at the pumping station 2b, and fed to the pipeline network 5, having previously filled the water tower 6.

Water supply systems can be classified according to the following criteria:

- for the intended purpose (water supply systems of localities (cities, towns), industrial water supply systems (industrial water pipelines), agricultural water supply systems);

- by the nature of the natural sources used (water pipelines that use water from surface sources, water pipelines that draw underground water; mixed-type water pipelines);

- according to the method of water supply (gravity water pipelines, water pipelines with mechanical water supply (using pumps), as well as zone water pipelines, where water is supplied to certain areas by separate pumping stations).

In this paper, we consider the water supply system of the village, which has a population of 8761 people. The average water consumption for internal water supply and sewerage for a given population is calculated using the formula:

$$S = q_a N,$$

where q_a is the average water consumption per day per 1 person, N is the number of residents.

Taking the average consumption of cold and hot water of 200 liters per day per person, we get the daily consumption:

$$S = 200 \cdot 8761 = 17,52 \cdot 10^5 \text{ l/day}$$

The specific consumption per person was chosen with consideration of the sewerage and internal water supply for the use of the washbasin, sink, bath and shower. This is explained by the fact that we consider the water consumption required for household needs (drinking water, water for cooking, water for cleaning, washing dishes, etc.). We calculate the consumption of cold water for household and drinking needs. It is known that the consumption of hot water on average is 40 % of the total water consumption for household and drinking needs

$$S_{hot} = 0,4S = 7,01 \cdot 10^5 \text{ l/day}$$

then the consumption of cold water is

$$S_{cold} = 0,6S = 10,51 \cdot 10^5 \text{ l/day}$$

The difference between the values S_{cold} and S_{hot} is the flow rate of water used for food S_{dr} and S_t used in the toilet:

$$S_{cold} - S_{hot} = S_t + S_{dr} = 3,5 \cdot 10^5 \text{ l/day}$$

The rate of consumption of drinking water for 1 person is approximately 7 liters per day

$$S_{dr} = 7 \cdot 8761 = 0,61 \cdot 10^5 \text{ l/day}$$

The water consumption for flushing in the toilet will be:

$$S_t = 2,89 \cdot 10^5 \text{ l/day}$$

That is, every day in a village with a population of about 8,000 people, 289,000 liters of purified water with a traditional water supply system will be flushed in the toilet. If we multiply this volume by the average cost of a cubic meter of water (34 tenge, we get 982 thousand tenge per day. It can be assumed that the introduction of a three-pipe water supply system will be more economically feasible.

Conclusions

The transition to a three-pipe supply of water of different quality will allow you to save significantly, due to the purification of water intended only for food.

Taking into account the smplification of the proposed energy supply technology of the gas turbine design and the exclusion of the system for cleaning combustible volatile substances, the cost of electricity, heat energy and gaseous fuel for cooking will be quite acceptable for a family with medium and small incomes.

The technology being developed will provide remote villages with a relatively small population with most types of energy consumed at an affordable cost. The technology will be in demand in countries with a large territory with a low population density.

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ШАЛҒАЙДАҒЫ АУЫЛДЫҚ ӨҢІРЛЕР ҮШІН ЖЫЛУМЕН ЖӘНЕ СУМЕН ЖАБДЫҚТАУ ЖҮЙЕЛЕРІН ОҢТАЙЛАНДЫРУ

Аумақтық-климаттық ерекшеліктерді ескере отырып, орталықтандырылған энергиямен жабдықтаудан оқшауланған ауылдарды әртүрлі энергия түрлерімен қамтамасыз ету мәселелері қарастырылды. Үш құбырлы сумен жабдықтау жүйесі және белгілі бір ауылдың жағдайына бейімделген қатты отынмен жұмыс істейтін электрмен жабдықтау технологиясы ұсынылады.

Ұсынылған жеткізу әдістерін пайдалану электр энергиясына, жылуға, суға және газ тәрізді отынға шығындарды азайтады. Бұл орташа және аз табысы бар отбасылар үшін өте қолайлы болады.

Қолайлы жану жылуымен газ өндірудің сипатталған технологиясы Көмірді ішінара термиялық өңдеуге негізделген. Қатты отынды газға айналдыру оны электр энергиясы мен тұрмыстық қажеттіліктер үшін пайдалануға мүмкіндік береді (тамақ дайындау).

Кілтті сөздер: энергиямен жабдықтау, электрмен жабдықтау, сумен жабдықтау, жылумен жабдықтау, газбен жабдықтау.

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ОПТИМИЗАЦИЯ СИСТЕМ ТЕПЛО- И ВОДОСНАБЖЕНИЯ ДЛЯ УДАЛЕННЫХ СЕЛЬСКИХ РЕГИОНОВ

Рассмотрены проблемы обеспечения различными видами энергии удаленных изолированных от централизованного энергоснабжения поселков, с учетом территориально-климатических особенностей. Предложена трехтрубная система водоснабжения и технология энергообеспечения, работающая на твердом топливе адаптированная к условиям конкретного поселка.

Использование предложенных способов подачи позволит снизить затраты на электроэнергию, тепло, воду и газообразное топливо. Что будет вполне приемлемо для семей со средним и небольшим достатком. Описанная технология получения газа с приемлемой теплотой сгорания основана на частичной термической обработке угля. Преобразование твердого топлива в газ позволяет использовать его для получения электроэнергии и бытовых нужд (приготовление пищи).

Ключевые слова: энергоснабжение, водоснабжение, теплоснабжение, газоснабжение.

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