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Energy Saving Technologies with the Use of Heat Pumps

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Introduction

Price rise for energy carriers inevitably brings about the price rise for heat energy and finally the price rise for stuffs, which makes it necessary for a manufacturer to look for the new alternative sources and ways of saving traditional energy sources, effective use of secondary energy resources, including natural low temperature sources of heat. That is the reason why the use of energy saving technologies, heat pumps being one of them, acquires an ever increasing significance [2].

The use and manufacture of heat pumps (HP) in this country is being carried out with the great delay. The 90^{s} were characterized by the cut of demand for such innovative energy equipment as heat pumps. The reasons for that are well known. So a lot of machines and new developments which were already mastered proved to be out of usage.

The recent years gave real economic impetus for energy saving, which is determined by the increase of price for energy carries as well as by the changes in relation of electricity tariffs and prices for different kinds of fuel.

Heat pump units are effective in technological processes of processing and storing food raw materials here law temperature heat sources and secondary heat resources are used. Of self – sustained meaning is the use of heat pumps in the systems of heating and air conditioning of the food stuffs enterprises premises [8].

In many cases the requirements of ecological cleanness for methods of getting heat energy step forward.

Traditional systems of heat supply by using boiler – houses operating on various kinds of natural fuel are characterized by considerable irreversible losses. By using high quality organic fuel (gas, oil, coal) the combustion temperature exceeds 1000°C, while the customer weds low temperature heat – 70°–130°C [1].

From the thermodynamic point of view the most rational fuel consumption is attained at thermoelectric plants where high temperature heat of combustion is maximally used for producing electrical energy, and for heat supply – the heat carrier with temperature necessary for heating production premises and residential houses.

But the use of heat electric power plant (HEPP) may be irrational in many cases due to large losses at heat transfer for large distances or lack of need for such volumes of heat. For example, when the heat users are dispersed and at a large distance from each other or when the natural conditions do not allow it. In such areas the boiler – houses remain the main source of heat being the main reason of air pollution with sulfur oxides and other harmful substances for people.

The world dynamics of rising prices for sources and energy itself is of stable character. Of considerable importance is the fact that Russia's entering the WTO is followed by the price rise at the internal market which is connected will energy power engineering at the level of world prices. So saving of fuel and energy resources is an urgent task for Russia. It is even of greater importance for the Kaliningrad region due to its geographic separation from the vest of Russia, lack of necessary resources, rise of electricity consumption and necessity to provide its energy self sufficiency [3].

Research

The Kaliningrad state technical university has been carrying at research for using heat pumps (HP) in technological processes of fish processing for a number of years [9].

The research has been performed along the following lines:

1. The use of heat pumps in the systems of preparing air in cold smoking, drying and fish.
2. The use of HP for heating water in the closed aquacultures systems (CAS).

3. The use of HP in the autoclave water preparation systems (sterilization and pasteurization of hermetically packed products).

In the 90-s two experimental units for cold smoking of fish were made at two fish processing enterprises of the Kaliningrad region. The modernized unit Н10-ИВЦ-1-03 produced 120 tons of products for the term of this unit was characterized by a better quality. The shore based fish processing complex in Pionersky town saw modernization of unit for continuous cold smoking of fish. For the term of one year it produced 4640 tons of product marked by a better quality. The economic effect owing to modernizations amounted to more than 95000 USD [6, 7].

The use of HP in autoclave water preparation systems (sterilization and pasteurization) is associated with energy saving in these processes. Thus documents regulating this process do not allow secondary use of water after autoclave. So, by using HP it is possible to return the warmth for heating water going into autoclave, which gives considerable economy of heat energy and cats environment pollution.

Cutting volumes of commercial fisheries brought about intensive development of aquaculture in many countries which made it possible to meet the fish products demands of population. The leading countries in this field, such as China, India, Japan, Norway and Chili supply their products not only the internal market but are also active on the world market. Having a great potential, Russia lags behinds by aquaculture indexes. In recent years the necessity of developing Russian enterprises that could have supplied the population with not expensive and fresh products has attained a State scale [10].

The overwhelming majority of methods used for running aquacultures farms prove to be useful in social sphere, providing foodstuff products with little or no harm for environment.

The closed water supply units (CWSU) prove to be the highest form of industrial fish culture, allowing to creating the optimal conditions for fish breeding all the year round both for supplying fish fry and commercial fish. It is the CWSU that provide the highest output of fish products per the square unit. Expediency of large development of this trend of industrial fish culture is based on the economy of water taken from under earth and other sources (daily water feedings is 5…25 % of the total volume), ecological cleanness, because it gives an opportunity for full or

partial utilization of fish metabolism and organisms, residing in biofilters and avoiding their coming into open water systems.

Within CWSU the block for thermal water preparation is not only one of the most important but also one of the most energy consuming ones. Taking into consideration variety of hydrobionts bred in industrial fish culture, it is necessary to point out a broad range of temperature modes for their optimal growth even within one life cycle. Thus low temperature is necessary for ripening and it is to rise gradually from fry to marketable fish. There are optimal temperature modes for growing marketable fish to facilitate their growth. This 14–18°C is optimal for trout, 23–28°C – for carp, 18–23°C – for sturgeon, 25–30°C – for sheat-fish, 25–32°C – for tilaphia. So aquacultures farms with heat, but also to cool water supplied to system. And it is also to be taken into account that technology presumes 5–20% change of the whole water volume, circulating in CWSU. It is obvious that development of aquacultures farms using heat pumps for water preparation may facilitate appearance of new possibilities for rising effectiveness of fish culture from ripening roe to growing marketable fish. This will result in obtaining competitive product in both internal and foreign market. Taking into account the high cost of breeding fish in CWSU at the present stage of aquacultures development, it is used for breeding expensive fish species (eel, sturgeon) and fish capable of maximum gaining weight for the shortest period of time (tilaphia, sheat-fish) [4,5].

The use of plant for thermal water regulation of CWSU for fish culture makes it possible to solve this task but with taking into account large volumes of water for circulation and supply of fresh water.

To investigate operation of cheat pump within the system of water preparation of CWSU n experimental unit was made. Its chart is presented on fig.1; fish cultural part of CWSU is presented on fig.2.

HP unit MSR-J072WLC was mounted and tested in the international aquacultures center of the KSTU (Svetly). The Tests were carried out in summer and winter seasons. The technical water from well was used as a source of low-potential warmth. The change of water temperature was not large – 8°–10°C.

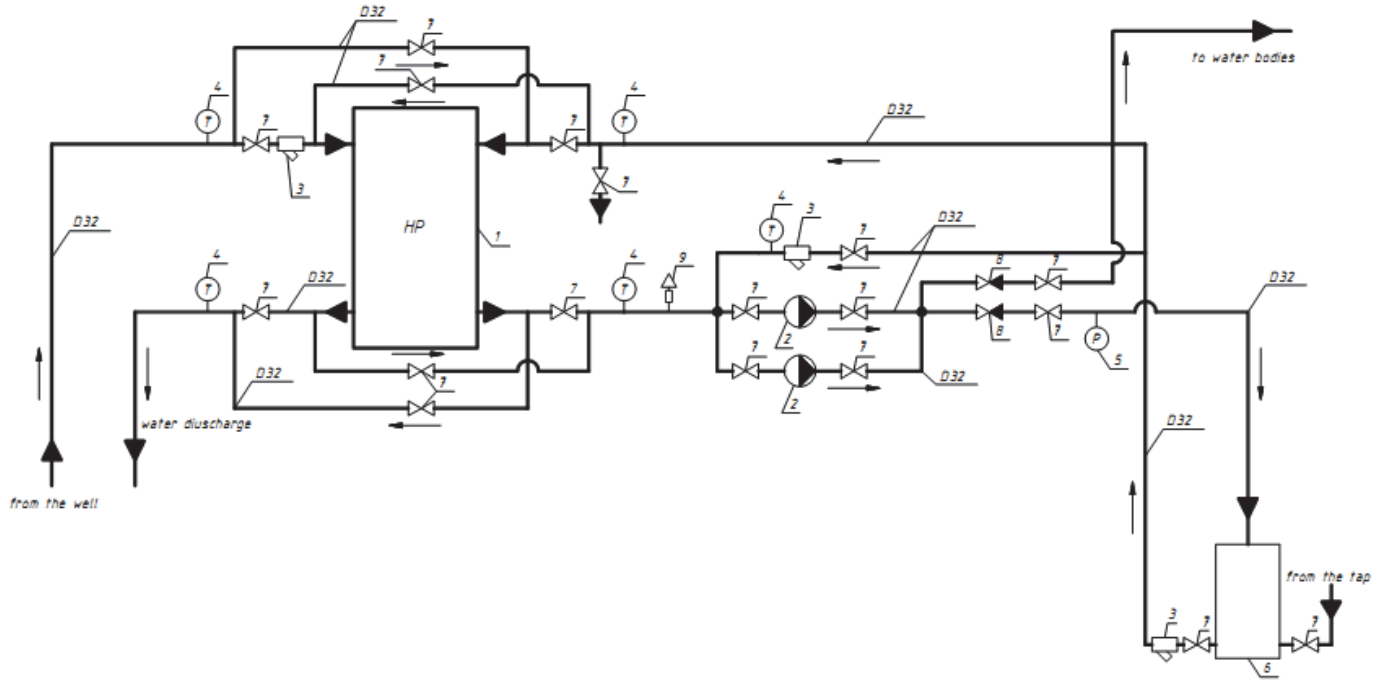

Fig. 1. The chart of experimental HP unit for thermal preparation of water; 1 – HP unit, 2 – water pumps, 3 – filter, 4 – thermometer, 5 – pressure-gauges, 6 – accumulator tank, 7 – valves, 8 – check valves

Rys. 1. Plan eksperymentalnej instalacji pompy ciepła do przygotowania wody; 1 – pompa ciepła, 2 – pompy wody, 3 – filtr, 4 – termometr, 5 – czujniki ciśnienia, 6 – zbiornik akumulacyjny, 7 – zawory, 8 – zawory zwrotne

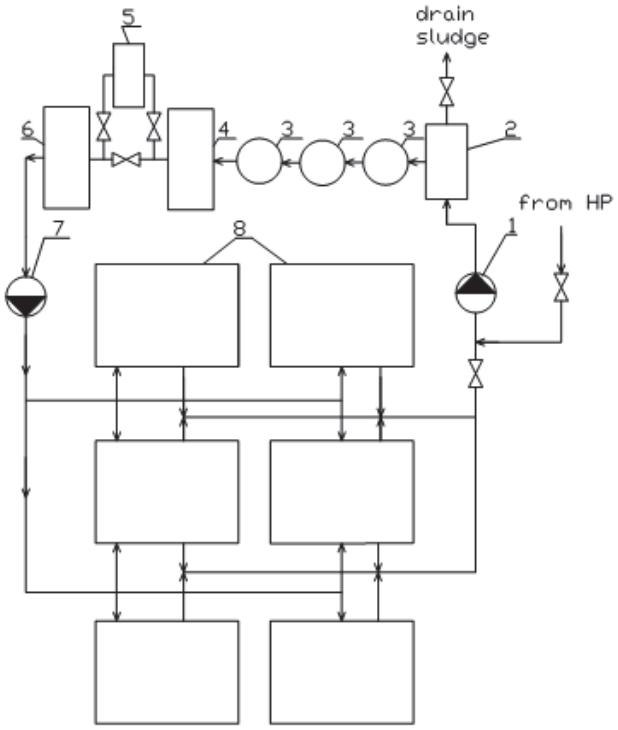

Fig. 2. Fish culture portion of closed water supply; 1 – water pump, 2 – mechanical filter, 3 – biofilters, 4 – bactericidal lamp, 5 – oxygenator, 6 – consumption tank, 7 – water pump, 8 – fish culture water bodies
Rys. 2. Zamknięty obieg zaopatrzenia w wodę w farmie rybnej; 1 – pompa wody, 2 – filtr mechaniczny, 3 – biofiltry, 4 – lampa bakteriobójcza, 5 – natlenianie, 6 – zbiornik zasilający, 7 – pompa wody, 8 – stawy rybne

Fig. 3, 4 show the dependence graph of electric power used by heat pump engine and energy transformation ratio on time of operation in heating up mode of water for feeding the system.

It is clear from graph (fig.3) that power used by 1 kWt at constant temperature and pressure in evaporator of HPU for 35 min of operation, which is accounted for by constantly increasing temperature and pressure in condensate of HPU, corresponding increase of pressure relation P_k/P_0, decrease of feeding ratio of HP.

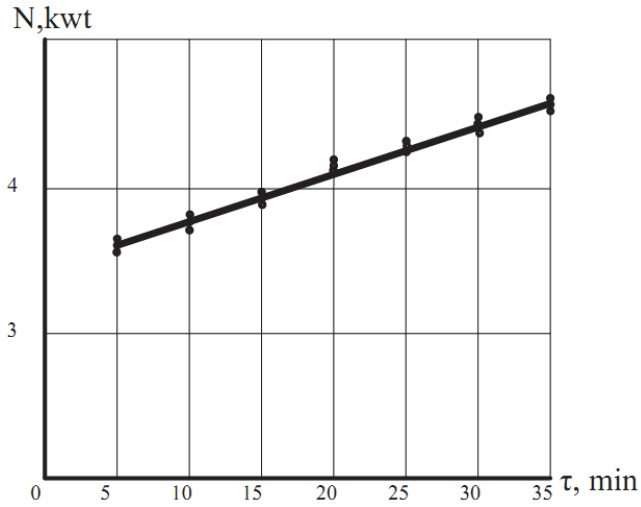

Fig. 3. Dependence of electric power used by HP engine on time
Rys. 3. Zależność zużycia energii elektrycznej przez silnik pompy ciepła od czasu

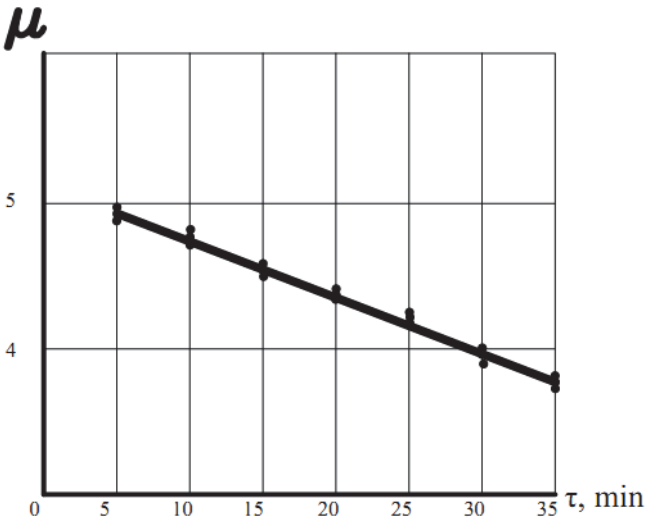

Fig. 4. Dependence of transformation energy ratio on time used by HP engine on time
Rys. 4. Zależność współczynnika przemiany energii od czasu pracy silnika pompy ciepła

At the same time the energy transformation ratio of HPU (fig.4) drops from 4.94 to 3.83, which is explained by the same reasons. The cost of water heating preparation after mounting a heat pump was cut by 3 times compared to the electric heating system which was earlier operated.

Considering prospects and possible field of use for heat pumps in fish culture it necessary to point out that because of the traditional structure and practice of designing heating and refrigeration systems for food production technological processes the use of heat pumps is unreasonably undervalued. Taking into account the present trend for sharp increase of investments for the production purposes the ample use of heat pumps on the food-staff enterprises seems quite expedient and promising.

Conclusions

An experimental heat pump unit for water thermal preparation in the CWSU was developed. Experimental data supporting its energy saving effectiveness were obtained. Effectiveness of using unit for thermal water regulation is confirmed by netting electrical energy consumption at condensing water, which is 3 times less than by conventional modes.

Maintaining set water parameters in conditions of daily feeding 20% water to CWSU from thermoregulation unit at the stage of keeping producers, 50% – at incubation and growing larval, 10–20% – at growing fry and marketable fish, made it possible:

- to obtain high quality and timely spawn products,
- to solve growth potential and health at all stage of biotechnical process,
- to make effective use of advantages of polycyclic technologies of fish culture in CWSU.

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Energooszczędne technologie wykorzystujące pompy ciepła

Streszczenie

Wzrost cen nośników energii w sposób nieunikniony powoduje wzrost cen energii cieplnej i ostatecznie wzrost cen artykułów spożywczych. Powoduje to konieczność poszukiwania przez producentów nowych, alternatywnych źródeł i sposobów oszczędzania tradycyjnych źródeł energii, efektywnego wykorzystania zasobów energii wtórnej, w tym naturalnych, niskotemperaturowych źródeł ciepła. To jest powód, dla którego stosowanie energooszczędnych technologii, pompy ciepła są jedną z nich, nabiera coraz większego znaczenia.

W pracy przedstawiono eksperymentalną instalację pompy ciepła do przygotowania cieplnej wody w zamkniętym obiegu zasilania w wodę. Dane eksperymentalne pokazują skuteczność w oszczędzaniu energii. Wydajność przy zastosowaniu urządzenia do regulacji temperatury ciepłej wody potwierdza zużycie energii elektrycznej dla wody kondensacyjnej, która jest trzy razy mniejsza niż w tradycyjnych rozwiązaniach.

Słowa kluczowe:
pompa ciepła, oszczędność energii, akwakultura, eksperymentalna jednostka pompy ciepła

Keywords:
heat pump, energy saving, aquaculture, experimental heat pump unit