ENERGY, ECOLOGICAL AND ECONOMIC ASPECTS OF EFFICIENCY OF STEAM COMPRESSOR HEAT PUMP INSTALLATIONS WITH ELECTRIC DRIVE, AS COMPARED WITH ELECTRIC BOILERS OPERATION FOR HEAT SUPPLY

Olga Ostapenko
Candidate of Engineering Sciences, Ph. D, Associate Professor,
Associate Professor of the Department of Heat Power Engineering,
Vinnytsia National Technical University,
Vinnytsia, Ukraine

ЕНЕРГЕТИЧНИЙ, ЕКОЛОГІЧНИЙ ТА ЕКОНОМІЧНИЙ АСПЕКТИ ЕФЕКТИВНОСТІ ПАРОКОМПРЕСІЙНИХ ТЕПЛОНАСОСНИХ УСТАНОВОК З ЕЛЕКТРИЧНИМ ПРИВОДОМ В ПОРІВНЯННІ З РОБОТОЮ ЕЛЕКТРИЧНИХ КОТЛІВ ДЛЯ ТЕПЛОПОСТАЧАННЯ

Ольга Остапенко
к. т. н., доцент,
доцент кафедри теплоенергетики,
Вінницький національний технічний університет,
м. Вінниця, Україна

Introduction. Considerable increase of natural gas price in Ukraine and growth of tariffs for heat energy stipulate the search of new highly efficient sources of heat supply. Usage of heat pump installations (HPI) in heat supply systems will provide the economy of fuel and protection of the environment as a result of reduction thermal pollution and amount of harmful emissions of combustion products, according to [1 - 4]. For determination of energy efficiency of usage of initial energy of the fuel and impact of certain type of heating on the environment, the Commission of Heat Pump of European Economic Community (EEC) in 1991 performed the analysis of heating systems, widely used in Europe. The results of the analysis [5; 6] are shown in table 1.

Table 1. Indices of heating systems (according to EEC data) [5; 6]

Heating system	Energy efficiency of initial energy, %	CO_2 emission, kg/kW
Electrical heating	35	0,55
Liquid fuel boiler, hot water heating	80	0,29
Gas-fired boiler, hot water heating	90	0,21
Heat pump with electric drive	110	0,22…0,14
Absorption heat pump	130	0,17
Heat pump with gas-engine drive	150	0,12

Aim of the research is determination of energy and ecological advantages and economic preconditions of usage of steam compressor heat pump installations with electric drive and different sources of low-temperature heat for operation in heat supply systems, as compared with electric boilers operation; evaluation of energy, ecological and economic efficiency of HPI, as compared with electric boilers operation, in heat supply systems.

Presentation of the material. The study of energy, ecological and economic aspects of efficiency of HPI with thermal capacity 1 MW with electric drive, at various sources of low-temperature heat, on condition of annual operation of HPI and variable temperature modes operation during the year was performed. Energy, ecological and economic efficiency of steam compressor HPI was compared with the efficiency of alternative source of heat supply (electric boiler house). The schemes of the above-mentioned HPI are presented in [7]. Energy efficiency of HPI was evaluated by the index of equivalent fuel saving. For electric hot-water boilers and HPI with electric drive, the consumption of equivalent fuel while electric energy generation at electric power stations was evaluated. Reduction of CO_2 emissions while using 1 MW HPI as compared with the operation of electric hot-water boiler of the same capacity is evaluated. CO_2 emissions during electric energy generation at electric power plants (for electric boilers and HPI with electric drive) were taken into account. For evaluation of the amount of CO_2 emissions statistical data from the researches [5; 6] (see table 1) were used. Table 2 show the results of complex assessment of energy-ecological-economic efficiency of HPI with thermal capacity 1 MW, with electric drive, as compared with the operation of electric boiler house in heat supply system.

Table 2. Indices of energy, ecological and economic efficiency of HPI with electric drive, as compared with the operation of electric boiler house, in heat supply system

Source of low-temperature heat for HPI	Annual economy of equivalent fuel (in %) for HPI	Annual reduction of CO_2 emissions (in %) for HPI	**Annual cost saving on electric energy and emissions for HPI,** mil. Hrs/yr
Heat of the soil and air	67,60	62,18	17,47
Heat of surface and ground waters	68,89	63,69	17,83
Heat of sewage waters	69,89	64,87	18,12
Heat of recycling water of circulating water supply system	74,12	69,44	19,31
Heat of geothermal waters and industrial heat emissions	81,94	76,59	21,49

Conclusions. The results of the research of energy, ecological and economic aspects of efficiency of HPI with electric drive, at various sources of low-temperature heat, for operation in heat supply systems, as compared with electric boilers operation, are presented in the given research. As it is seen from Table 2, that the economy of equivalent fuel, annual reduction of the amount of CO_2 emissions and annual saving of finance resources on electric energy and emissions are observed for all the studied variants of HPI application with electric drive, with different low-temperature heat sources for HPI, as compared with electric boilers operation for heat supply.

References:

1. Ostapenko, O. P. (2019). *Study of energy-economic efficiency of energy supply systems with cogeneration heat pump installations, using the heat of the industrial and natural sources, in industry and municipal heat power branch of Ukraine*. Social and Legal Aspects of the Development of Civil Society Institutions (pp. 292 – 308). Warsaw: Institute of European Integration, Bmt Eridia Sp. zo. o. [in English]

2. Ostapenko, O. P., Leshchenko, V. V., & Tikhonenko, R. O. (2015). Energy advantages of application of steam compressor heat pumps with electric and cogeneration drive. Scientific Works of Vinnytsia National Technical University, 1. Retrieved from: http://works.vntu.edu.ua/index.php/ works/article/view/437/435. [in English]

3. Ostapenko, O. P., Bakum, Y. V., & Yuschishina, A. V. (2013). Energy, ecology and economy aspects of the efficiency of heat power stations operating on natural and industrial heat sources. Scientific Works of Vinnytsia National Technical University, 3. Retrieved from: https://works.vntu.edu.ua/index.php/works/article/ view/384/382. [in English]

4. Ostapenko, O. P. (2016). Scientific basis of evaluation energy efficiency of heat pump plants. Saarbrücken: LAP LAMBERT Academic Publishing. [in English]

5. Draganov, B. Kh., & Mishchenko, A. V. (2006). K voprosu o teplovykh nasosakh. Promyshlennaya teplotekhnika, Vol. 28, 2, 94 – 98. [in Russian]

6. Ostapenko, O. P., & Slobodianiuk, A. M. (2014). Energy, ecological and economic efficiency of steam compressor heat pump plants as compared with alternative sources of heat supply. Scientific Works of Vinnytsia National Technical University, 2. Retrieved from: https://works.vntu.edu.ua/index.php/works/article /view/412/410. [in English]

7. Ostapenko, O. P. (2015). Refrigeration equipment and technology. Heat pumps. Vinnytsia: VNTU. [in Ukrainian]