Renewable Energy Sources in Hot Water Supply System

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***Abstract* – possibility of renewable energy sources use in heat water supply system has been studied. Potential renewable energy sources to be effectively used in Lviv climatic zone have been analysed, and their main advantages and disadvantages have been shown. Efficiency of use of vacuum solar collectors and "air-water"-type heat pump in hot water supply system has been ascertained based on the analysis of performance of the facility operating at Lviv Polytechnic National University.**

Key words – energy efficiency, renewable power engineering, solar collectors, heat pump, hot water supply.

I. Introduction

Rise of urban population and advance of requirements to social conditions quality considerably increase demand for electrical and heat energy. Continuous increase of urban demand for heating and hot water supply is directly connected to increase of organic fuel consumption, consequently increasing amounts of harmful atmospheric emission and worsening of environmental situation in general. Considering these factors, the issue of renewable energy sources utilization, including energy of sun, wind, floods, geothermal heat, biomass, becomes more and more urgent. These energy sources are environmentally friendly and not hazardous for environment. Besides, they are practically inexhaustible, unlike conventional organic energy carriers [1]. Use of technologies based on renewable energy sources would enable to decrease organic fuel consumption and enhance environmental situation in our state.

Utilization of nonconventional power engineering becomes more and more urgent for Ukraine, taking into account increase of prices for energy carriers, in particular natural gas, being used for heating and hot water supply of domestic buildings, as well as a fuel at many Ukrainian thermal power plants and heat electropower plants. Considering the acute political situation in the state, this fuel becomes deficient because amount of gas extracted in Ukraine is insufficient to satisfy needs for it in full. The situation concerning coal is also difficult, as most of it is extracted in the mines of Donetsk coal basin, and because of hostilities in Ukrainian East coal extraction is almost stopped.

Practical utilization of nonconventional and renewable energy sources in Ukraine is behind world level. Main obstacles for their implementation include low specific power, high capital cost, low level of state support and absence of experience of continuous exploitation.

Choice of certain renewable energy source is determined by its availability and possibility to be efficiently used. Thus, heat of ambient air as a renewable energy source is characterized by temperature fluctuations over season and day depending on weather conditions. That is why the heat of ambient air is reasonable to be used in climatic zones with rather high (not less than +5 °C) temperature and stable weather conditions.

Considerable temperature fluctuations in heating period along with often and long thaw in winter are typical for Lviv climatic zone. Use of ambient air heat as an energy source is expedient only in transition periods (autumn–winter, winter-spring), as well as during winter thaws in daylight.

Expedience of solar energy use strongly depends on climatic conditions of the region. Potential of this energy source is rather high but density of solar radiation flow is comparatively small – about 0.6 – 0.8 kW per 1 m^2. This requires considerable absorbing surfaces areas of solar collectors. In addition, this source has another considerable disadvantage – solar radiation comes unevenly. This requires to use heat accumulating devices for both day and season accumulation.

It is impossible to use potential of mentioned energy sources directly in heating and hot water supply systems, and use of certain technical facilities intended for collecting, transformation and transferring energy to ultimate consumer, are needed. Heat pumps are used to utilize ambient air heat, and solar collectors are used to utilize solar energy.

Heat pump is a device for transferring heat energy from the source of low potential heat energy (with low temperature) to the heat carrier with higher temperature. In terms of thermodynamics, heat pump is analogous to refrigerating machine [2].

Two physical phenomena underlie the operating principle of most widespread steamcompressive heat pumps:

- absorption and release of the heat by a substance when changing its aggregate state – vaporization and condensation, respectively;
- change of vaporization (and condensation) temperature when changing pressure.

Solar collectors are devices for collection of the Sun energy transferred by visible light and infrared radiation. The solar collectors, which are the main element of solar water heating and heat supplying facilities, are made of available materials (steel, copper, aluminium etc.), i.e. without usage of expensive silicone, being used to produce photoelectric cells for electric power generation, and this allows to decrease considerably the cost of the equipment and the energy generated by it. Nowadays, water heating by the Sun is the most efficient way of solar energy utilization.

There are two most widespread types of solar collectors: vacuum solar collectors and flat solar collectors [3]. Vacuum solar collectors are more efficient.

II. Research-and-Production Facility of Nonconventional Energy Sources Utilization

Research-and-production facility of Renewable Energy Sources Laboratory of Lviv Polytechnic National University was used to study the issues of efficiency of ambient air heat and solar energy utilization.

The research-and-production facility of nonconventional energy sources utilization is intended for hot water preparation using a system of solar collectors and "air-water"-type heat pump. The energy obtained from the heat sources is transferred to two hot water reservoirs of 500 litres each. In the first reservoir heated by vacuum solar collectors NSC 12-58 GREENEN, fitted with tubes HEAT-PIPE, preliminary heating of water takes place. The heat produced in solar collectors is transferred to the reservoir through tubular heat exchanger (coil pipe) or high-speed plate heat exchanger, fitted to the facility. Three-way valve is used in the facility to commute heat carrier flow from solar collectors between the reservoir and high-speed heat exchanger. "Air-water"-type heat pump of 10 kW is connected to the second reservoir. Heated water is supplied from the reservoirs into hot water supply network of students' canteen.

Devices connected to the hot water reservoirs are controlled by DigiENERGY controller, fitted with the counter of produced and consumed energy, with possibility of writing down and real time review of all the parameters of the facility. Water-glycol mixture is used as a heat carrier in the system of solar collectors and the heat pump. This ensures no-failure operation of the facility at ambient temperature up to -35 °C.

During the operation of the facility electric energy is used only for drive of circulating pumps and the heat pump compressor, and the amount of electric energy consumed is much less then amount of heat energy produced.

To analyze the facility efficiency we carried out the research aimed on determination of the energy consumed by the heat pump and the solar collector, and the energy produced by them over a month (March 2015). Based on the results obtained it has been ascertained that:

- amount of electric energy consumed by the solar collector over a month is 214 kW·h;
- amount of heat energy generated by the solar collector over a month is 585 kW·h;
- amount of electric energy consumed by the heat pump over a month is 584 kW·h;
- amount of heat energy generated by the heat pump over a month is 1185 kW·h.

Previous analysis of the renewable energy sources and the obtained results of the facility operation show that solar collectors efficiency is limited by daylight time duration and cloudiness, while heat pump efficiency is limited by air temperature. Daylight time duration at latitude of Lviv in March is 12 hours on average (10 h. 59 min. for Mach 1st and 12 h. 51 min. for March 31st). The analysed period was characterized by high cloudiness, 22 days among 31 days (2 fine and 7 low cloudy days), and average temperature +4.2 ºC.

Conclusion

Based on the analysis of the results obtained and weather conditions under which the facility operated, it has been ascertained that high cloudiness and short daylight time resulted in rather low productivity of solar collectors, and low average air temperature resulted in low productivity of heat pump. However, even in such unfavourable period of the facility operation we managed to decrease heat consumption from the university boiler-house, wherein natural gas is used as an energy source.

References

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