POSSIBILITIES OF HEAT PUMP USAGE FOR HEATING PIGLET RESTING PLACES

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Abstract. In order to save and rationally use energy, more and more attention is paid to the use of heat pumps. Producers and disseminators of heat pump systems have accumulated certain experience in the use of them for individual house heat supply, mainly in the form of floor heating. It is possible to use the heat energy obtained by a heat pump for different processes of agricultural production, including piglets, both suckers and weaned, resting place heating. For experimental purposes the heat pump Octopus IS 81 with nominal power of 17 kW has been bought. At the end of October 2008 it was arranged in a piggery with 96 farrowing places. During November and December examination of the equipment operation was carried out and some results obtained. We have established that different exploitation conditions in dwelling houses and live-stock premises demand careful estimation of a heat pump type for the use in pigsty. The more essential factor, effecting the heat pump operation, is temperature, which for dwelling house floor heating is about 25-30 ˚C, but for piglets resting place heating by concrete floor panels within the limits of 35-40 ˚C.

Keywords: heat pump, coefficient of performance, piglet, heating panel.

Introduction

During the first weeks of sucker life in its resting place the temperature should be 32-35 ˚C, which gradually is decreased till 22-24 ˚C when weaned. For weanling the temperature in its resting place has to be kept within the limits of 27-22 ˚C [1]. The maintenance of such comfort demands to supply additional energy. The necessary power of a heater is determined by several factors: design of a resting place, external climate conditions, as well as heat loss of the building. When the piglets resting place is arranged rationally, the necessary power of the heater is 250 W on the average, and usually does not exceed 400 W [2]. Due to increasing price of electric energy, piglets heating with electric heaters, infrared lamps and electric mats more and more seldom are used. In case, when piglet resting places with concrete floor panels, warmed by hot water, are equipped, for the maintenance of the necessary panels surface temperature hot water boiler is used. As a fuel, usually depending on local possibility, cheaper or available material like firewood, coal, natural gas, liquefied gas and other is used. At present the average price for energy carriers, the price of fuel for piglet resting place heating is within 45-125 Ls per pen. The stock of fossil fuel is limited. Besides that the use of fossil fuel is connected with pollution of the environment. Therefore, in the whole world more and more attention is paid to economic use of traditional energy recourses, as well as alternative and renewable energy sources. One of the solutions at the use of renewable energy is implementation of heat pumps in heat supply systems. In Latvia some experience in the use of heat pumps for heat supply of dwelling houses and different public building is accumulated. The use of heat pumps in heat supply systems for technological processes in agriculture is not enough investigated. In many cases sellers and disseminators of heat pump systems are not competent and able to give some reasonable recommendations on the installation and use of this equipment. There are some peculiarities and differences when the heat pump system is used on a live-stock breeding farm, including piglets resting place heating:

1. Piglet resting place has to be heated evenly during all the year round, but not only in cold period of a year;
2. Heat pump has to work in the range of temperature 22-36 ˚C instead of 20-22 ˚C as for dwelling houses;
3. On cattle breeding farms it is possible to repeatedly use the outgoing air heat for the heating cold incoming outside air, when the ventilation system is working.

The objective of the research is to find the solution of these questions.

Materials and Methods

The research has been carried out by analyzing technological possibilities and technical parameters of presently produced types of heat pumps in respect to corresponding them to the

requirements defined for the use of piglet resting place heating in pig barns. In the result of the analysis the more suitable type of heat pump for the determined conditions has been chosen and examined at real production condition in a farrowing pigsty, supplied with floor heating by heated concrete panels. During the experimental investigation the following has been registered: temperature of the heat carrier (water) at the start and end of heating loop (HOBO sensors, accuracy 0.02 ˚C), amount of circulated water (water flow meter, accuracy 0.0001 m^3), and amount of energy consumed by the heat pump (2 electric meters, accuracy 0.01 kWh). According to the obtained experimental results, the heat power consumed for piglet resting place heating, as well as power for heat pump operation has been calculated.

The efficiency of heat pump operation is characterized by the energy transfer coefficient or coefficient of performance (COP), that is, the ratio between the amount of heat energy obtained from the heat pump, and work, consumed for heat pump operation, and it can be calculated by formula [3]

$$K = \frac{Q}{P}, \tag{1}$$

where K – coefficient of performance;
Q – amount of obtained heat energy, J;
P – work consumed for heat pump operation, J.

Results and discussion

Considering the application possibilities of different sorts of heat pumps from every point of view (ground heat, water heat, air heat), the preference has been given to the air heat pump with water heating in the secondary loop. The air heat pump COP depends on the outside air temperature and the necessary temperature of the use. The coherence between the COP and the surrounding air temperature is shown in Fig. 1 [4-6].

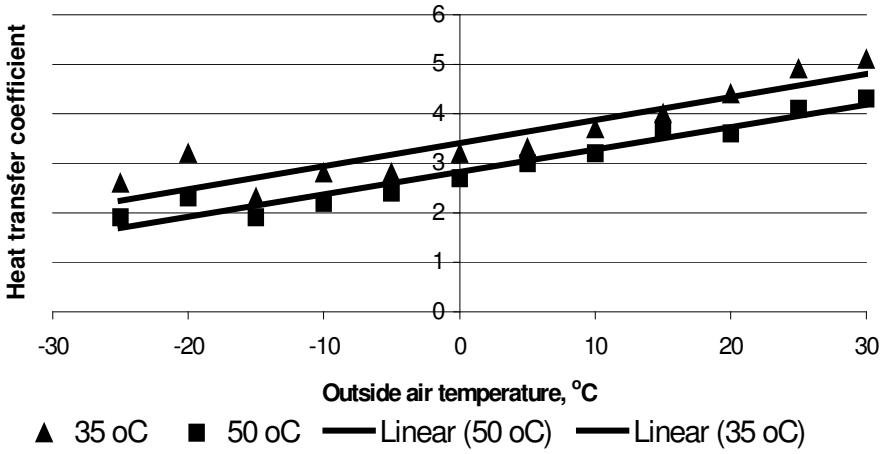

Fig. 1. **Average energy transfer coefficient of outside air heat pump at the necessary temperature 35˚C and 50 ˚C (published data)**

As it is seen, the COP is higher at positive temperature. It means that comfortable conditions for the use of the heat pump on the average will be 9 months a year. The highest COP would be in summer months. It is relevant favorable difference in comparison with the conditions, when a heat pump is used in dwelling houses mainly in winter months, and the COP is the lowest. In this case additional warming is needed using other heating possibilities.

In order to insure the necessary air change in warmed cattle-breeding premises, a lot of heat energy is lost through the operating ventilation system. The deviation of the warm inside air flow to the outside placed heat pump evaporator, can considerably rise its COP during winter months, so insuring the necessary heating power. For implementation of such a solution, less available is a heat pump with a radiator type evaporator, because of the possibility that the plates of the evaporator are getting choked with dust and other particles existing in the flow of warm inside air. From that point of view less dangerous are heat pumps with passive vertical evaporators. On the base of the analyzed

results, for practical experiments a heat pump produced by the company OCTOPUS (Sweden) has been chosen. An agreement with a pig farm, where concrete panels floor heating by hot water is already installed, on the experimental investigation of the heat pump has been reached. In one of the piggery sections 96 farrowing pens were arranged. The necessary heating power for one pen is approximately 180 W. It means that the total power necessary for floor heating is about 17 kW. It was stated that for this power the heat pump IS 81 corresponds best. The technical characteristic of the heat pump is given in Table 1.

Table 1

Technical characteristic of heat pump OCTOPUS IS 81

Parameters	Unity of measure	Value
Evaporators – vertical radiators	number	2
Heat carrier – R290 (propane)		
Power of Scrol type compressor	kW	5
Operational pressure of the compressor, min/max	bar/bar	1.5/23
Productivity	m^3h^{-1}	19.2
Average power of produced heat energy	kW	17
Maximal temperature of circulation water	˚C	55
Power of additional electric heater	kW	9

In Fig. 2-4 the heat pump installed in the piggery and piglets resting place warmed by hot water heating panel is shown.

Fig. 2. **Evaporators of heat pump IS 81**

Fig. 3. **Compressor of heat pump IS 81 with heat exchanger (container on the right), control unit and measuring equipment (on the left)**

Fig. 4. **Farrow pen with hot water heating plastic panel in new born piglet resting place**

In November 2008 the first operational data of the heat pump IS 81 were obtained. After arrangement and adjustment the heat pump was working from 10 to 26 November 2008, completely insuring new born piglets resting place with floor panel heating. The concrete panel surface temperature within the limits of 34-36 ˚C has been maintained. The experimental results obtained during this period of time are presented graphically in Fig. 5.

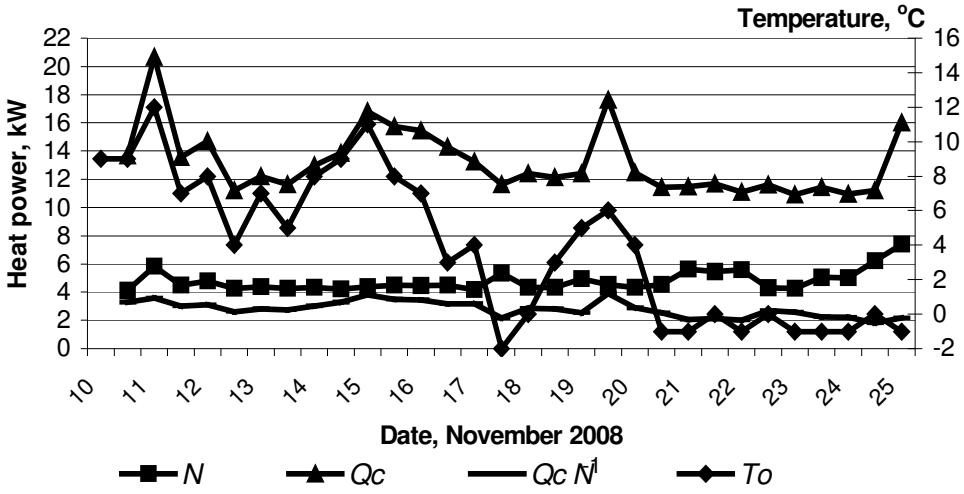

Fig. 5. **Results of heat pump experimental investigation on 10-26 November 2008:** *N* – power consumed; *Qc* – consumed heat power; $Qc\ N^{-1}$ – ratio of power; *To* – outside air temperature

Conditionally it is possible to divide the period of experimentation in two parts: the first one, when the outside air temperature was above +4 ˚C, and another, when the outside air temperature was about 0 ˚C. The experimental results are different, and presented in Table 2. The position of evaporators during the experiment can be seen in Fig. 6.

Table 2

Results of heat pump experimental investigation in different periods depending on outside air temperature

Period	Number of days	Outside air temperature, ˚C	Power of compressor, kW	Power of obtained heat, kW	Ratio of power	Additional power*, kWh
1	8	+4 ... +12	4.4	14.0	3.1	1.2
2	6	+3 ... -2	4.2	12.3	2.4	12.0

*Additional electric energy consumed in order to reach the necessary temperature in both periods.

Fig. 6. **Evaporators covered with hoarfrost during exploitation**

From the graphs in Fig. 5 it is seen that during the days, when the outside air temperature reached 11-12 ˚C (11 and 15 November), the produced by the heat pump heat power reached its maximum, that is, 17-20 kW, and the COP was above 3.8.

After processing the obtained experimental data on the whole period, the average results are as follows. The average power for the heat pump operation – 4.6 kW; obtained average heat power – 12.7 kW; COP – 2.75. For the heat pump running consumed electric energy is 1770 kWh (126 Ls). The produced and consumed heat energy for floor heating – 4871 kWh. In order to produce this amount of heat the farm would have to consume 390 kg liquefied gas (0.59 x 390 = 230 Ls). During two weeks obtained economy from the difference of the consumed and produced energy makes: 230 – 126 = 104 Ls. Analyzing the observations and results it is stated that different exploitation conditions and regime in dwelling houses and live-stock premises demand careful estimation of a heat pump type for the use in the pigsty. A more essential factor, effecting the heat pump operation, is different necessary heating temperature, which for the dwelling house inside premises is about 20-23 ˚C, but for heating piglets resting places by concrete floor panels, its surface temperature has to be 36 ˚C. It means that the heat pump has to work at a higher temperature regime, which is near to its maximum. As the efficiency of an air heat pump essentially is affected by outside air temperature, the investigation has to be continued and the operational parameters established for spring and summer seasons too, when the COP is expected to take the highest value. At operation of the heat pump during cold weather periods it would be useful to examine different ways of COP increase. It is envisaged to continue the investigation on the use of heat pumps in different objects of agricultural production in 2009 and in winter of 2009/2010.

Conclusions

1. The use of heat pumps for piglets resting place heating gives certain increase in energy consumption.
2. The actual economic efficiency of the heat pump operation can be calculated by taking into consideration the experimental results obtained both in winter and summer time.

References

1. Liellopu un cūku mītnes: tehnoloģija un aprīkošana. Profesora Jura Priekuļa redakcijā. – Rīga, 2003. – 198 lpp.
2. A. Ilsters Aprīkojums un izmaksas cūkkopībā. – Rīga, 2001. – 171 lpp.
3. Dagnija Blumberga Siltuma sūkņi. – Rīga, 2008. – 139 lpp.
4. ExoAirPolaris – Technical Description [viewed 2009-02-16]. [viewed 2009-02-16]. Available: http://www.drafts.lv/fotos/pdfsPBExoAirPolaris_9-0709-308_EN.pdf
5. Compact series 10 kW. Data sheet. [viewed 2009-02-16]. Available: http://www.dealec.co.uk/acatalog/pdf/stiebel/stiebel10.pdf
6. User Manual. Thermia. [viewed 2009-02-16]. Available: http://www.thermia.se/docroot/dokumentbank/Thermia_user_086u6297_EN.pdf