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CHANGEABILITY OF HEAT OUTPUT OF HEAT PUMP WITH SCROLL TYPE COMPRESSOR

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Summary. The paper presents results of examination of a heat pump with scroll type compressor, manufactured by Vatra SA. The statistical analysis carried out, revealed significant impact of the upper and lower heat source temperatures on the heat pump power output, and the dependency obtained presents the qualitative and quantitative influence of those factors.

Keywords: heat pump, heat pump power output, lower upper heat source temperature, alternative power engineering.

INTRODUCTION

In the times of rapid development of digital techniques, we are facing the greatest ever energy demand, which is mostly satisfied by fossil fuel resources. When assuming constant exploitation of primary energetic resources on an unchanged scale, there will be enough oil for 100, gas for 150 and coal for another 200 years. Such forecasts encourage reasonable fossil fuels management and further reduction of their usage, followed by replacement with alternative energy sources.

The heat pump is one of the devices allowing the usage of renewable low-temperature energy sources [Szlachta 1999]. Such energy can be acquired from both the natural resources and industry. This sort of energy is very cheap, and sometimes even completely free.

Over hundred-years history of cooling equipment and the resultant experience has turned the heat pumps manufactured nowadays into highly reliable and efficient machinery. Therefore, they greatly contribute to energy saving. Modernization of any heat generating plant by introducing a heat pump increases its energetic efficiency, expressed as the ratio of the sum of energy effects (mechanical or electric energy and heat) and the fuel chemical energy used. It is also important, that the heat pumps pose no risk to the environment, as compared to the traditional heat energy sources. The only obstacle faced while using them, is the higher investment cost, however, the operating cost is significantly lower than that of traditional heating equipment.

Compressor heat pumps are used for heating residential and industrial space, for heating tap water, as well as in industrial processes, in agriculture and food industry [Nawrocki, Myczko 1998a, 1998b Szlachta 1999, Paliwoda 2001], which results from a great versatility of heat sources, which are of relatively low temperature but offer high heat capacity. However, before installing compressor heat pumps in a heating circuit, not only an economic analysis has to be made, but also the demand for heat power must be assessed to safeguard proper performance of a heat generating plant. To meet this requirement, it is essential to carry out field tests, aimed at the determination of the actual characteristics for such equipment.

THE AIM OF THE STUDY

The paper was to carry out preliminary examination of a prototypic heat pump Vatra SA., provided with scroll type compressor. The results obtained have allowed the development of a model and usable characteristics, to describe the effective power generated by a compressor heat pump.

SUBJECT AND TEST METHODS

The subject of the tests was a compressor heat pump water-water type of power output 35 kW. The pump was tested in a test stand in the manufacturer works (Vatra S.A.), according to PN-EN 255, applicable to the heat pumps. The pump tested is fitted with two plate exchangers by Friga-Bohn of 40 kW each, and a compressor unit of motor rated power 12.5 kW.

During the tests, the parameters of both, the lower and upper energy sources were recorded; in particular, the following were measured: the fluid volume flow in the upper and lower source, the temperature at the inlet and outlet of the exchanger, supply and return pressure from heat exchangers, temperature of superheated coolant fumes, and the electric power drawn by the compressor unit. The upper and lower source temperatures were measured with laboratory equipment of the 1st accuracy class, and the obtained results were recorded in a PC. The measurements were made during stabilised operation.

The heat capacity of the upper heat source of the compressor heat pump was determined with the direct method, based on the measurement liquid flow (radiating heat) and the temperature difference between the heat exchanger inlet and outlet. The statistical calculations were made by means of the STATISTICA application, and all hypotheses were verified for importance to the level $\alpha = 0{,}05$.

RESULTS OF THE STUDY

Based on the results of tests of the compressor heat pump of water-water type, power output 35 kW, the key operating parameters have been established, such as: the energetic efficiency coefficient [Trojanowska et. al. 2005], and the power supplied to the upper source of heat. The power delivered by the heat pump, and especially its changeability, is of critical importance, as its practical applications are decided based on that parameter. The value, for each measuring point, has been determined directly, according to the following dependency:

$$P = \dot{m} \cdot c_w \cdot \Delta t \tag{1}$$

where: P– upper heat source power output [kW],

– mass flux of the operating medium in the upper heat source $\left[\frac{kg}{s}\right]$,

– specific heat of the operating medium in the upper heat source $\left[\frac{kJ}{kg \cdot \deg}\right]$

– temperature difference of the operating medium in the inlet and outlet of the upper heat source [deg].

Based on the carried out statistical analysis, it was found, that the temperatures of both, the upper and lower heat sources had a significant effect on the compressor heat pump power output. The effect of such factors on power output is well described in the linear regression equation of two variables, which was achieved with the determination coefficient $R^2 = 0.95$:

$$P = 43,42 + 1,52 \cdot T_D - 0,26 \cdot T_G \tag{2}$$

where: T_D – lower heat source temperature [^{O}C],
T_G – upper heat source temperature [^{O}C].

A set of characteristics was developed based on the dependency (2), in order to illustrate the effect of the upper and lower heat source on the power output. As the presented dependency (2) and figures 1 and 2 illustrate, the lower source temperature is of different effect on the power output than that of the upper source. The power output is incremented by 1.52 kW, per 1°C increase of the lower source temperature (see Fig. 1). Firm dependency between the power output and the lower heat source temperature is quite obvious, and the quantitative assessment provides grounds for reasonable use of the potential resources of the selected heat source.

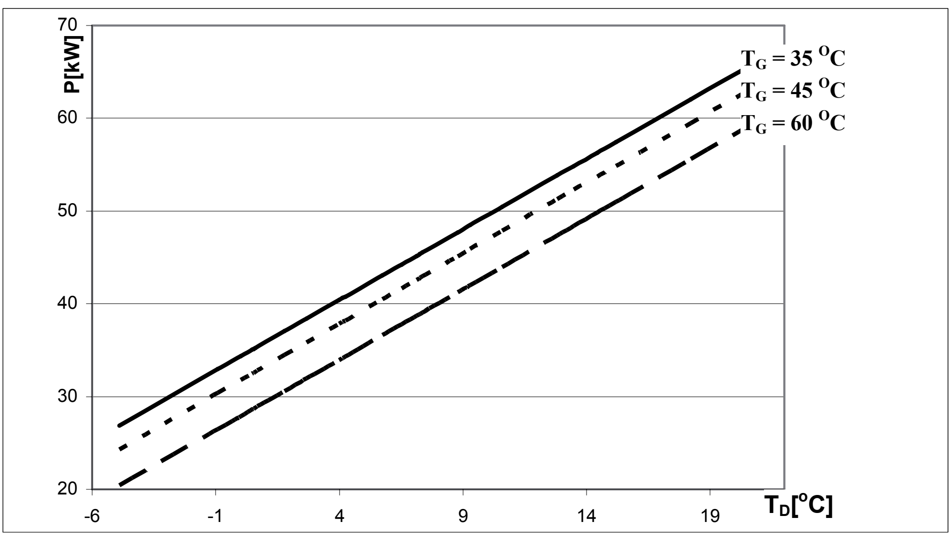

Fig. 1. The dependency between the compressor heat pump power output and the lower heat source temperature T_P

On the other hand, an increase of the upper source temperature by 1°C leads to the power output decrease by 0.26 kW. Such relatively insignificant effect of the upper source temperature on the power output, is beneficial from the practical point of view. This makes the compressor heat pump suitable not only for low-temperature heating systems (floor heating), but also in the cheaper conventional ones.

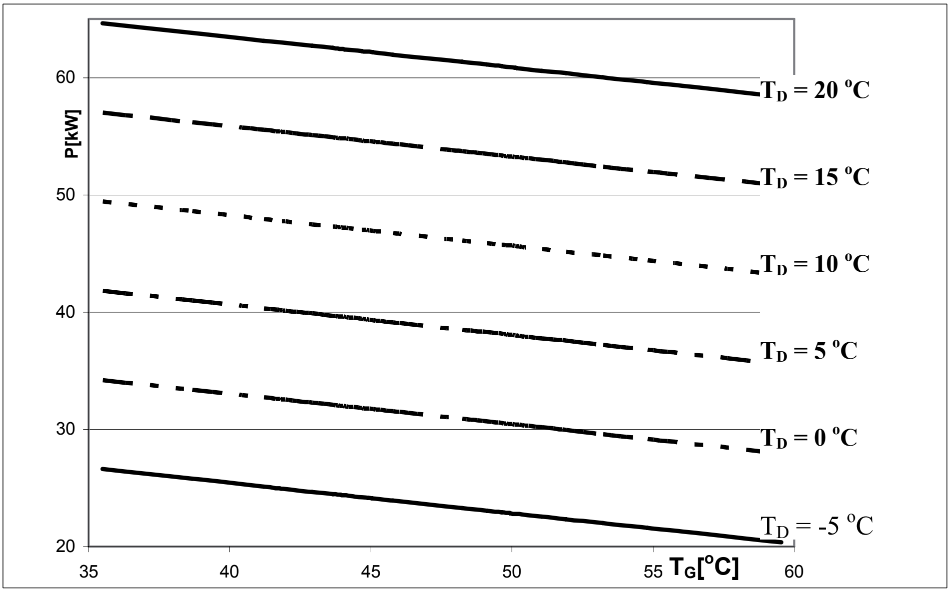

Fig. 2. The dependency between the compressor heat pump power output and the upper heat source temperature T_G

SUMMARY

Based on the statistical survey of testing the heat pump with scroll type compressor, it has become possible to obtain the dependency determining the quantitative and qualitative impact of both the upper and the lower heat source, on the effective power output, and the dependency (2) is particularly useful in terms of practical applications. A significantly weaker influence of the upper source temperature on the power output, contributes to widening the range of practical applications of the heat pump in power management. The noteworthy influence of the lower heat source temperature on the power output, however, calls for usage of auxiliary systems to the heat pump, which cooperates with a collector subject to significant temperature drops (in-ground collector).

Particular attention shall be drawn on the linear character of the dependency between the power and temperature in that type of heat pump, which considerably simplifies the process of control over the parameter, in contrast to heat pumps with piston compressors [Zimny et. al. 1998], where the power is described by a square dependency. However, in the heat pump with scroll type compressor, the power output depends more on the lower source temperature than in the case of that with a piston compressor. This makes them more practical in systems with higher temperature of a lower heat source, whereas the heat pumps with piston compressor are more suitable for lower temperatures of a lower heat source.

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