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FEATURES OF RESEARCH AND EVALUATION OF EFFICIENCY OF HEAT PUMP CYCLES WITH USING THE SOLKANE® PROGRAMS

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Abstract

The analysis of features of research and an estimation of efficiency of cycles of heat pumps with use of the Solkane® programs at training of experts in a specialty "heat power engineering" was carried out. The capabilities of the programi can be used for training specialists in the specialty "heat power engineering", which aims to study, design and evaluate the effectiveness of energy supply systems with heat pump installations, optimization of modes of operation of energy supply systems with heat pumps.

Key words: efficiency, cycle, heat pump, Solkane®, refrigerant.

Introduction

When training specialists in the specialty "heat power engineering" there is a need to study, design and evaluate the effectiveness of energy supply systems with heat pump installations (HPI), optimization of modes of operation of energy supply systems with heat pumps.

Calculations of heat pump efficiency indicators are performed using the specialized programs «SOLKANE® Refrigerants» and «SOLKANE® Software» [1 – 2], designed by science company «Solvay». «SOLKANE® Refrigerants» and «SOLKANE® Software» are the free powerful specialized programs for calculating the thermophysical properties of refrigerants and calculating the cycles of HPI. These programs calculates the thermodynamic properties of all Solkane refrigerants and a number of CFCs, contains modules for calculating various processes and cycles, as well as calculations of refrigerant pipelines.

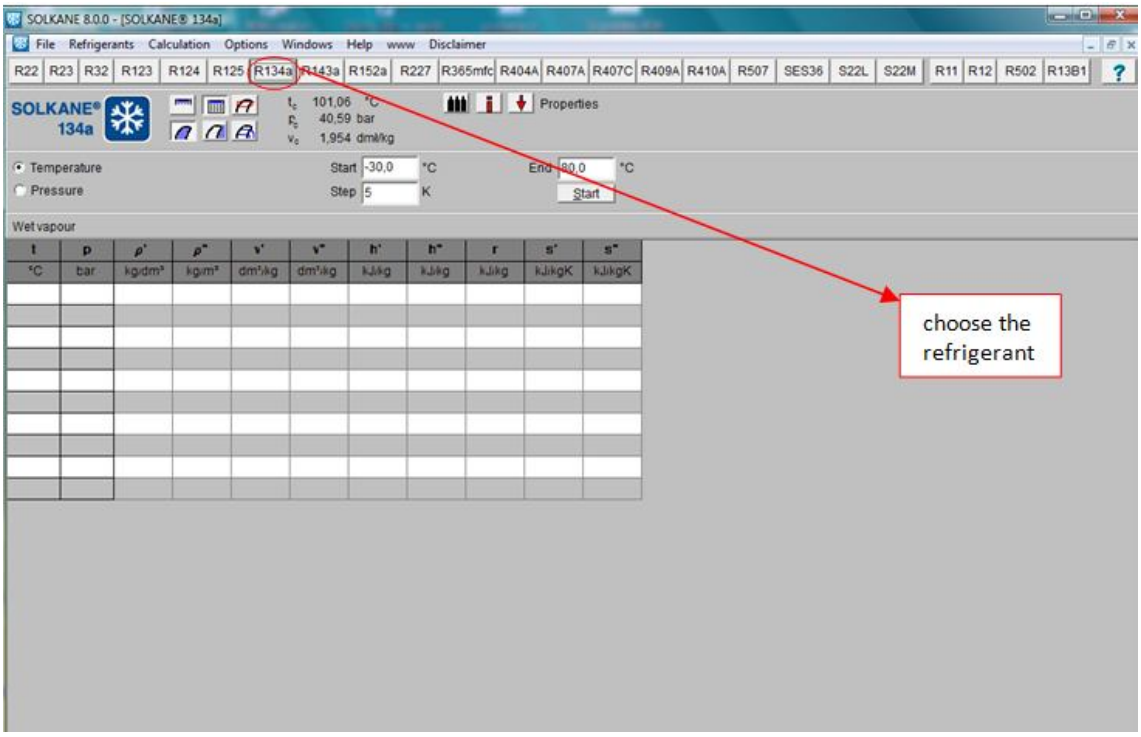
"SOLKANE® Refrigerants" and "SOLKANE® Software" are used by a number of European higher education institutions to train specialists in the fields of heat, refrigeration and cryogenic technology, food and processing industries [3 – 10].

Presentation of the materials

We will illustrate the possibilities of research in the program "SOLKANE® Refrigerants" on specific examples. To illustrate the capabilities of the program used materials from [3] and illustrations by the author. At the beginning of work with the program "SOLKANE® Refrigerants" it is necessary to choose the type of refrigerant from the offered in program. The choice of refrigerant is illustrated in Fig. 1.

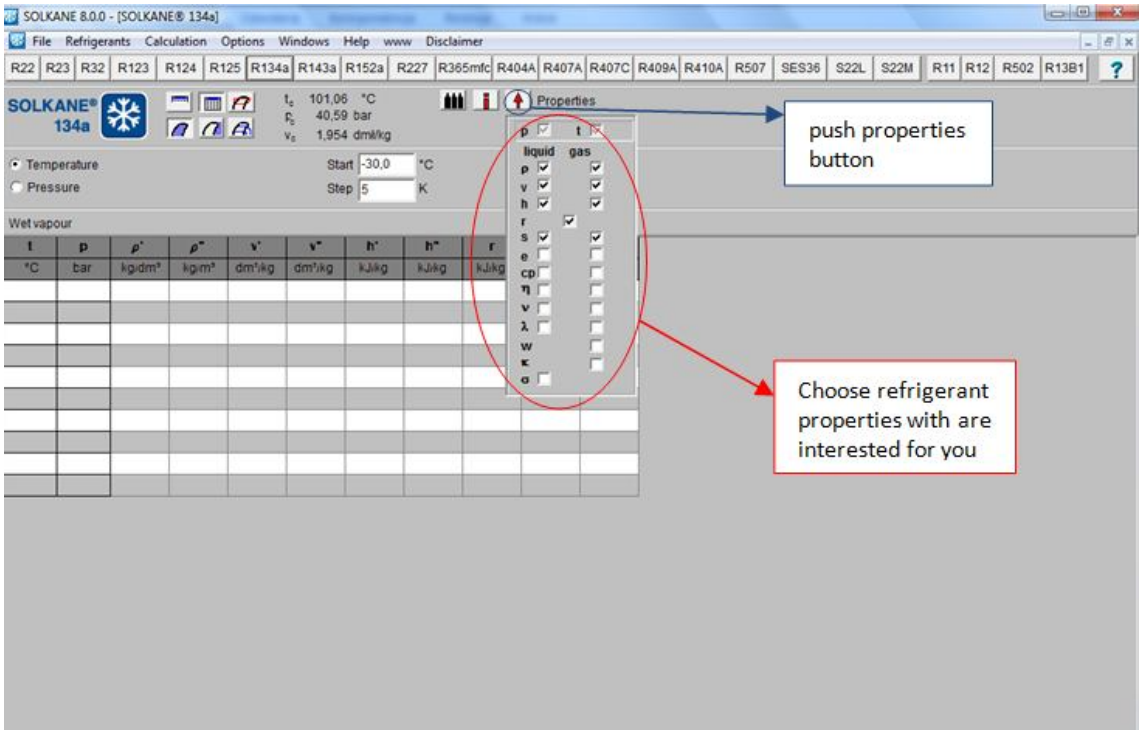
The program "SOLKANE® Refrigerants" allows to select the thermophysical,and thermodynamic properties of the refrigerant for different phase (see Fig. 2): density ρ, specific volume v, specific enthalpy h, enthalpy difference r, specific entropy s, specific exergy e, specific heat capacity Cp, dynamic viscosity η, kinematic viscosity ν, heat conductivity λ, acoustic velocity w, adiabatic exponent κ, surface tension σ. As is known from thermodynamics, these properties depend on saturation parameters: temperature t and pressure p.

The next step in working with the program"SOLKANE® Refrigerants" is to select the ranges of saturation temperatures (or saturation pressures), as well as the step of changing them to determine the properties of a particular refrigerant (see Fig. 3). Based on the entered data, the program generates a table of thermophysical and thermodynamic properties of the refrigerant for different phase (see Fig. 3).



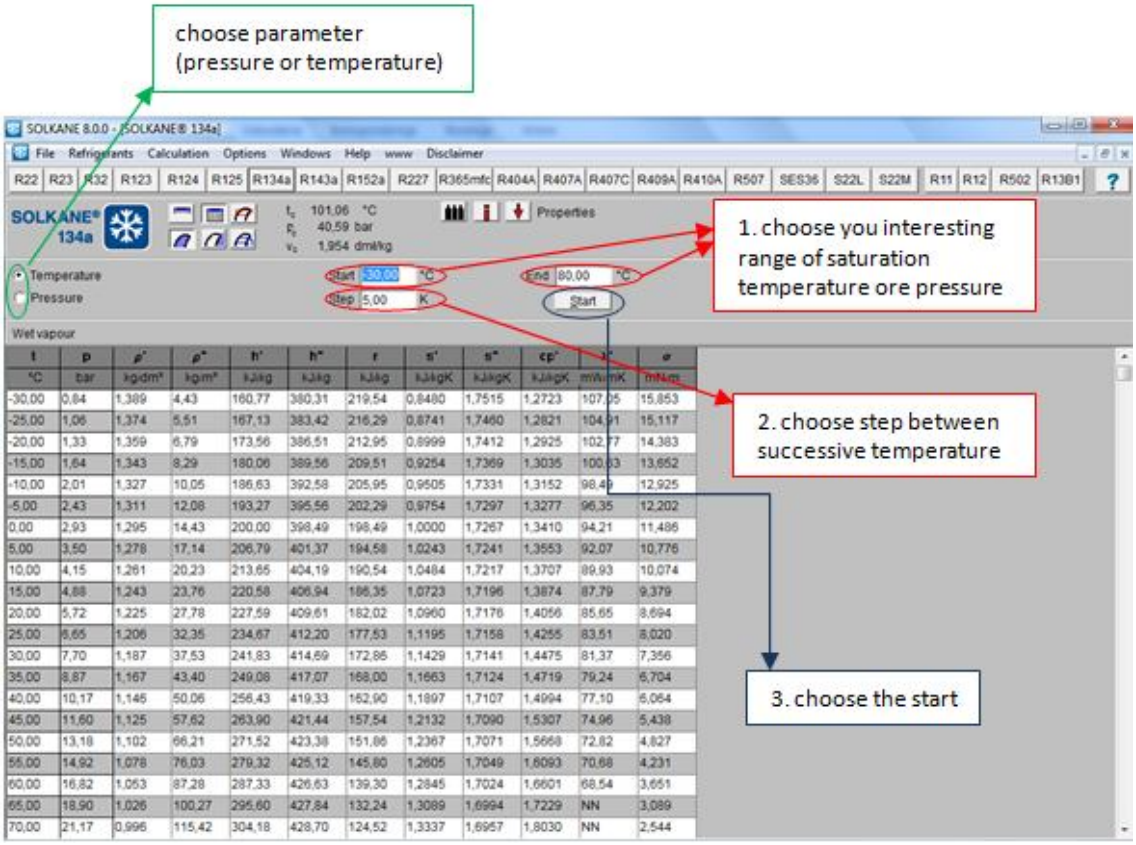
Source: [3].

Figure 1. Selection the type of refrigerant in the program"SOLKANE® Refrigerants" [3]



Source: [3].

Figure 2. Selection the thermophysical and thermodynamic properties of the refrigerant for different phase [3]



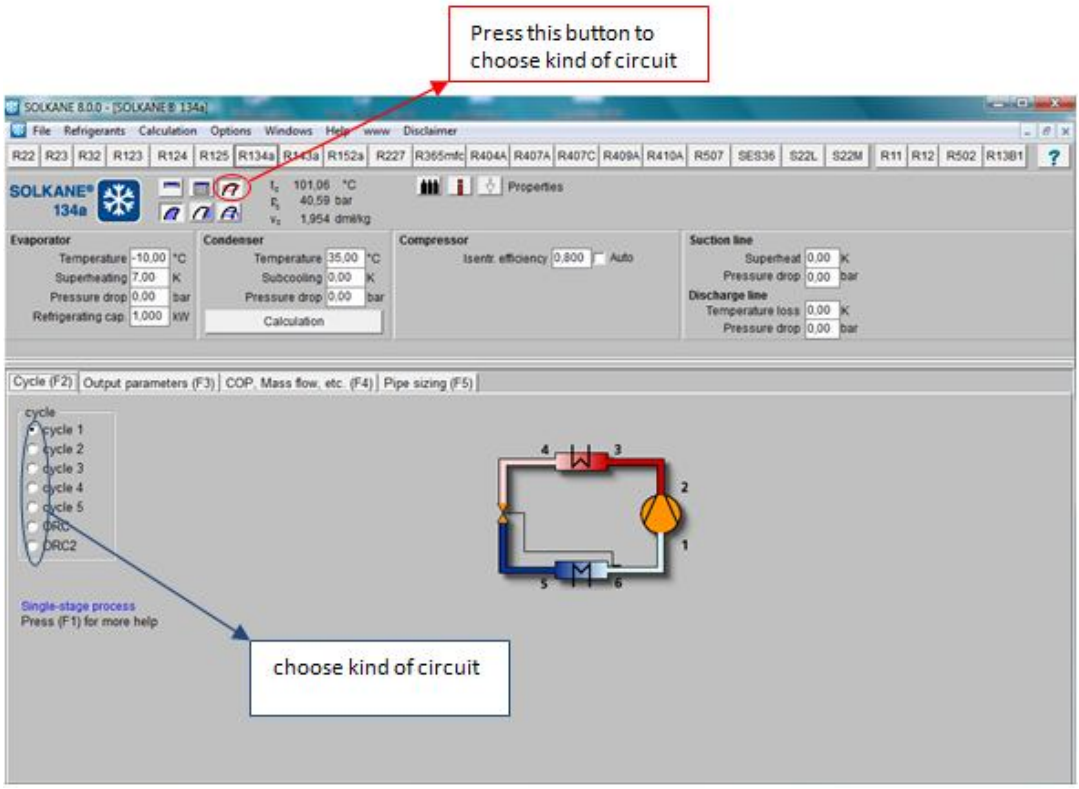
Source: [3].

Figure 3. The table of thermophysical and thermodynamic properties of the refrigerant for different phase, based on the entered data [3]

The refrigeration (or heat pump) cycle selection in the program "SOLKANE® Refrigerants" is shown in Fig.4. In Fig. 5 shows the input of initial data for the calculation of heat pump (or refrigeration) efficiency indicators for the selected type of cycle: the values of temperatures of evaporation and condensation, values of pressure drop, superheating and subcooling values, refrigerating capacity, isentropic efficiency of compressor, parameters on suction and discharge lines. For beginning of the calculation of heat pump (or refrigeration) efficiency indicators can be pressed «calculation» button (see Figs. 5, 6).

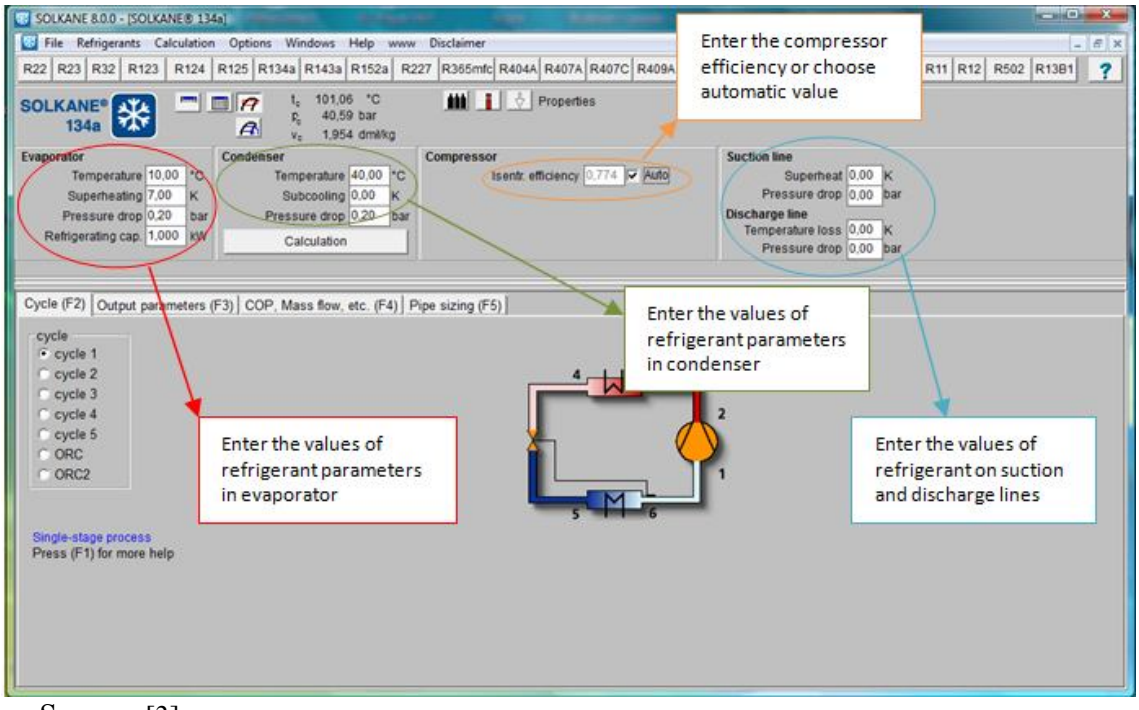
As a results of calculations of refrigeration (or heat pump) cycle are determined: output parameters for characteristic points of cycle (pressure ***p***, temperature ***t***, specific enthalpy ***h***, specific entropy ***s*** and measure of dryness ***x*** (see Fig. 6)). These parameters also can be found in characteristic points of cycle on «pressure – enthalpy» diagram (Fig. 7).

As a results of calculations of refrigeration (or heat pump) cycle also are determined such indicators of cycle efficiency (see Fig.8): ***COP*** (Coefficient of Performance, that is characterized the ratio of heating capacity to the electrical capacity that consumption of heat pump), thermal power capacity of evaporator and condenser, electrical power capacity of compressor, pressure difference, capacity ratio, etc.



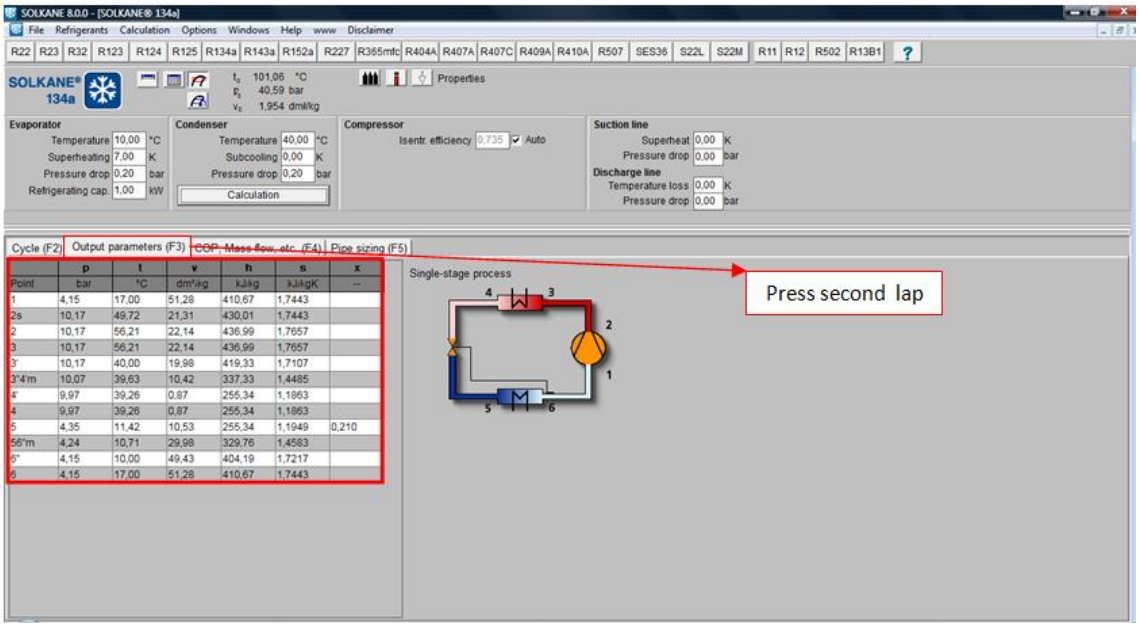
Source: [3].

Figure 4. Selection of refrigeration (or heat pump) cycle in the program "SOLKANE® Refrigerants" [3]



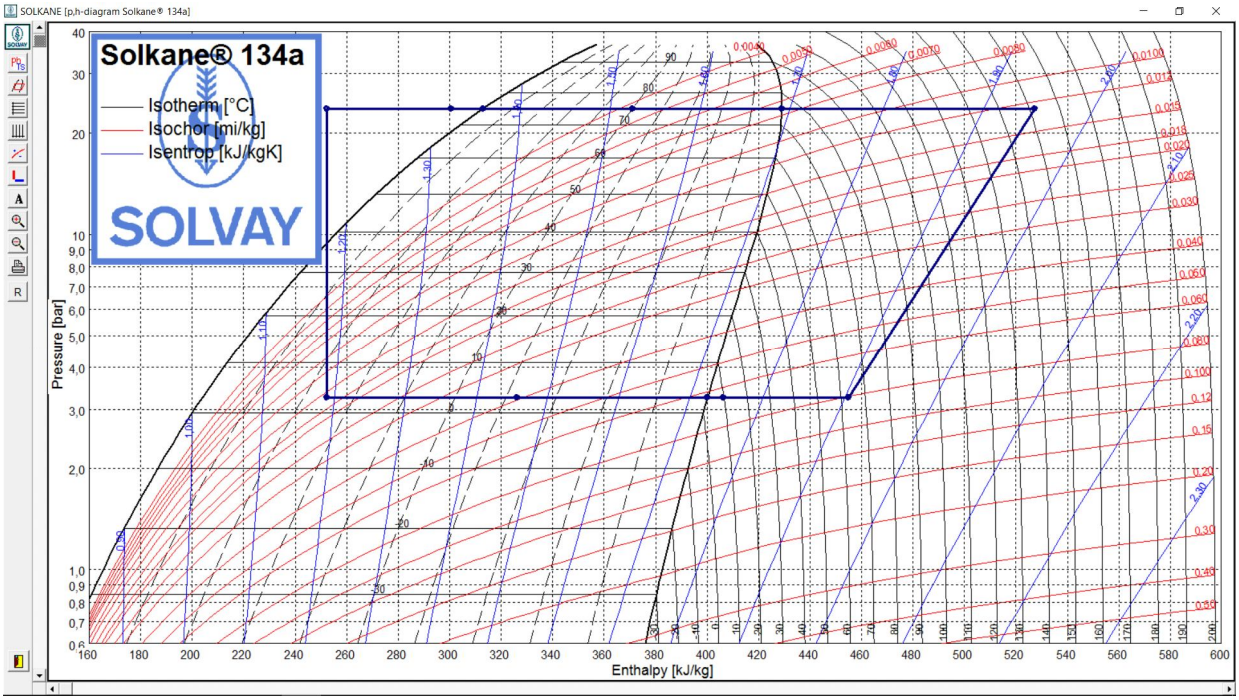
Source: [3].

Figure 5. The input of initial data for the calculation of heat pump (or refrigeration) efficiency indicators for the selected type of cycle [3]



Source: [3].

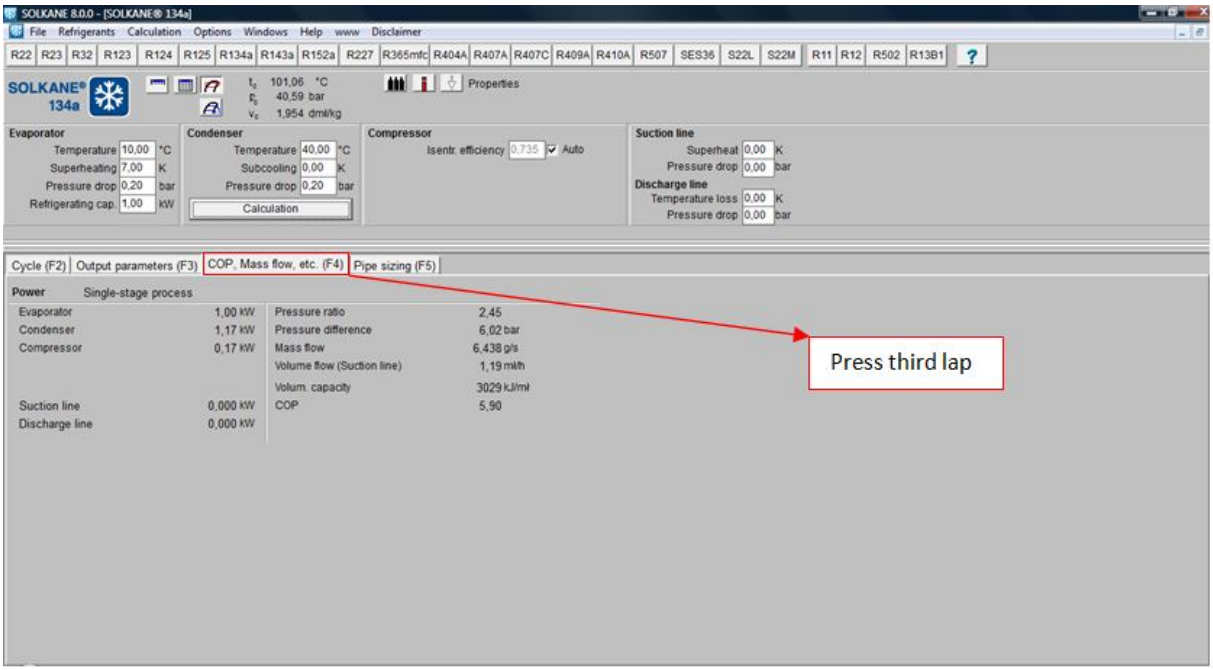
Figure 6. Heat Pump Cycle calculation results (parameters of circuit characteristic points) [3]



Source: author's data.

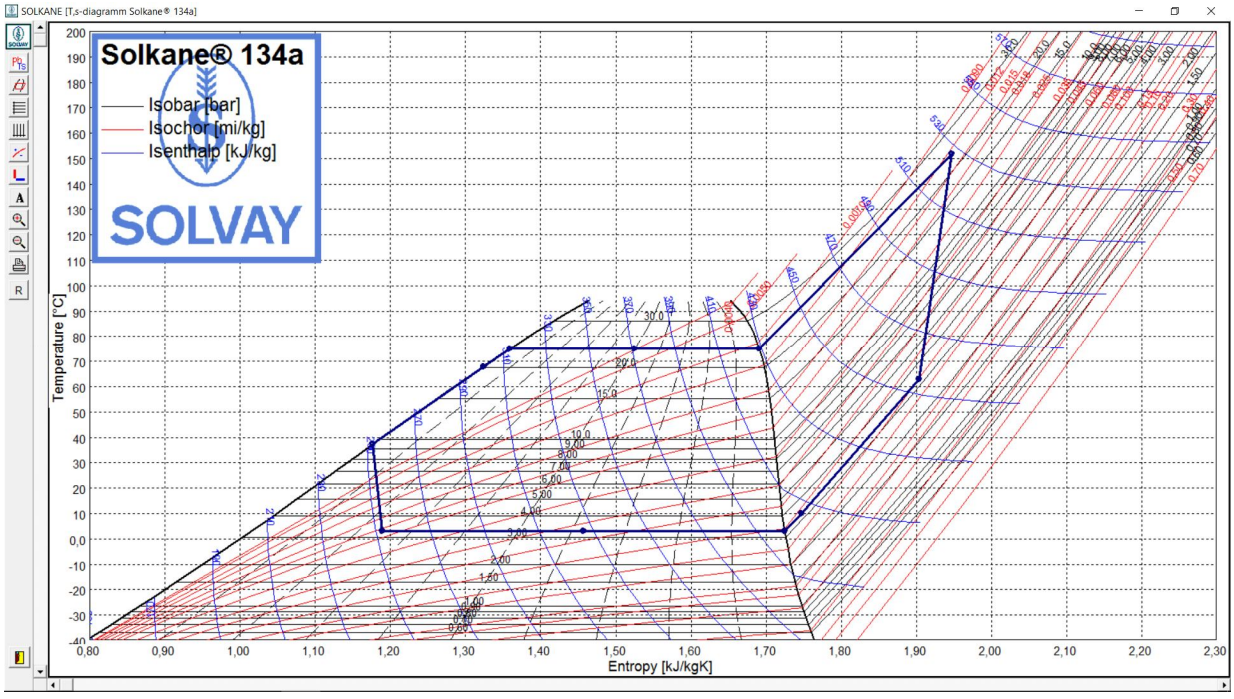
Figure 7. Heat Pump Cycle on diagram «pressure – enthalpy» in the program"SOLKANE® Refrigerants"

The parameters of refrigerant in the program "SOLKANE® Refrigerants" also can be found in characteristic points of cycle on «temperature – entropy» diagram (Fig. 9).



Source: [3].

Figure 8. Heat Pump Cycle calculation results (COP, mass flow, power consumption, etc.) [3]



Source: author's data.

Figure 9. Heat Pump Cycle on diagram «temperature – entropy» in the program "SOLKANE® Refrigerants"

In this paper, we analyzed features of research and evaluation of efficiency of heat pump cycles using the SOLKANE® programs. The capabilities of the program can be used for training specialists in the specialty "heat power engineering", which aims to study, design and evaluate the effectiveness of energy supply systems with heat pump installations, optimization of modes of operation of energy supply systems with heat pumps.

Conclusion

The analysis of features of research and an estimation of efficiency of cycles of heat pumps with use of the Solkane® programs at training of experts in a specialty "heat power engineering" was carried out.

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REFERENCES

1. SOLKANE Refrigerants 8.0 [Електронний ресурс]. – Режим доступу до ресурсу: https://solkane-refrigerants.software.informer.com/8.0/ (Дата звертання 10.03.21).
2. SOLKANE 9 Software [Електронний ресурс]. – Режим доступу до ресурсу: https://softadvice.informer.com/Solkane_9_Software. (Дата звертання 10.03.21).
3. Małgorzata Sikora. Parameters selection of a heat pump using the Solkane Software. Koszalin University of Technology. Retrieved from: unescochair.bntu.by. (Дата звертання 10.03.21).
4. Jozsef Nyers (2015). COP of refrigerants in heat pumps. 7th International Symposium on Exploitation of Renewable Energy Sources and Efficiency. Subotica, Serbia. Proceedings, pp 121-124. Retrieved from: https://www.researchgate.net/publication/277952751_COP_of_refrigerants_in_heat_pumps (Дата звертання 10.03.21).
5. Ostapenko, O. (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. Part I, (pp. 292 – 308). Warsaw: Institute of European Integration. Bmt Eridia.
6. Ostapenko, O. (2019). Analysis of energy, ecological and economic efficiency of steam compressor heat pump installations, as compared with alternative sources of heat supply, with accounting the concept of sustainable development. Sustainable Development Under the Conditions of European Integration. Part II, (pp. 312 – 329). Ljubljana:Visoka šola za poslovne vede.
7. Ostapenko, O. (2020). Estimation of energy-ecological-economic efficiency of energy supply systems with cogeneration heat pump installations in Ukraine, in the concepts of green logistics and sustainable development. Institutional Development Mechanism Of The Financial System Of The National Economy. (pp. 52 – 66). Batumi: Publishing House “Kalmosani”.
8. Ostapenko O. (2020) Estimation of efficiency of energy- and resource-saving heat pump technologies in Ukraine, in the concepts of Green Logistics and Sustainable Development. Modern Approaches to Knowledge Management Development, (pp. 174 – 186). Ljubljana:Visoka šola za poslovne vede.
9. Ostapenko, O. (2019). Application of the methods of green logistics and sustainable development for the synthesis of highly efficient systems of energy supply with heat pumps. Knoweledge management, economics and Law: proceedings of the 1st International Scientific conference (pp. 42 – 44). Batumi: Publishing House «Kalmosani».
10. Ostapenko, O., Savina, N., Mamatova, L., Zienina-Bilichenko, A. & Selezneva, O. (2020). Perspectives of application of innovative resource-saving technologies in the concepts of green logistics and sustainable development. Turismo: Estudos &Práticas (UERN), Mossoró/RN, Caderno Suplementar, 02. Retrieved from: http://natal.uern.br/periodicos/index.php/RTEP/article/view/1261/1202. (Дата звертання 10.03.21).

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