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COMPUTER PROGRAM FOR CALCULATION MICROCHANNEL HEAT EXCHANGERS FOR AIR CONDITIONING SYSTEMS

Creating a computer program to calculate microchannel air condensers to reduce design time and carrying out variant calculations. Software packages for thermophysical properties of the working substance and the coolant, the correlation equation for calculating heat transfer, aerodynamics and hydrodynamics, the thermodynamic equations for the irreversible losses and their minimization in the heat exchanger were used in the process of creating. Borland Delphi 7 is used for creating software package.

Keywords: *Microchannel condenser; Heat transfer; Hydrodynamics; Aerodynamics; Energy efficiency; Entropy-cycle method; Irreversibility; Entropy generation minimization; Techno-economic analysis.*

I. INTRODUCTION

The program devoted in solving a relevant scientific and technical problem. This problem is increasing the energy efficiency and ecological reliability of the refrigeration machines and heat pumps through introduction of new design types of the heat exchangers. New design types are based on miniaturization of equipment. Microchannel heat exchangers and, particularly, microchannel air-cooled condensers are discussed in the research.

In the research was developed the methodology for calculations of thermotechnical characteristics of the microchannel condensers based on mathematical models of heat transfer, fluid- and aerodynamics of two-phase flow of a working fluid within a microchannel, and of an air flow in a short channel of complex configuration.

Methods for the evaluation of the effectiveness of the heat exchangers were expanded in the research as well.

In the research, the theoretical principles for experimental investigation of a new generation of the heat exchangers were developed. The application of the analyzed methods for evaluation of effectiveness of the heat exchangers let us to apply the energy saving technology for the design process.

II. THEORETICAL PART

Intensive development of refrigeration engineering associated with a steady demand to improve the environmental safety and energy efficiency of manufactured equipment, runs in two directions: modernization of the piston compressor and new design of spiral, screw and centrifugal compressors and creation of new types of heat exchangers.

New types of devices with air as heat or cooling agent have been appeared at the market of refrigeration heat exchange equipment. The heat exchangers of this type are classified as compact microchannel heat exchangers. Microchannel heat exchangers entered into refrigeration from the automotive and aerospace industries. They are small-sized, made of aluminum alloy according to the latest technologies in the brazing furnace with gas control, for the intensification of heat transfer.

Few years ago, most experts in refrigeration industry were skeptical for using microchannel heat exchangers. Currently, a large number of chillers and heat pumps have been commercially available, which are completed by microchannel heat exchangers. Among the leader manufacturers such as Güntner, Danfoss should be called [1-2]. In 2008, at the Chillventa exhibition the Güntner company introduced an aluminum microchannel condenser for commercial refrigeration units. The company said that the operating pressure of the condenser can reach 41 bar., the mass of the heat exchanger is reduced to 50%, the capacity of the system with the refrigerant at the same performance of 75%, with the possibility of installation in the horizontal and vertical planes.

Researchers and practitioners in relation to the rapid development and implementation of new heat exchangers, have a lot of questions about the possibility of thermal engineering calculations and specifications.

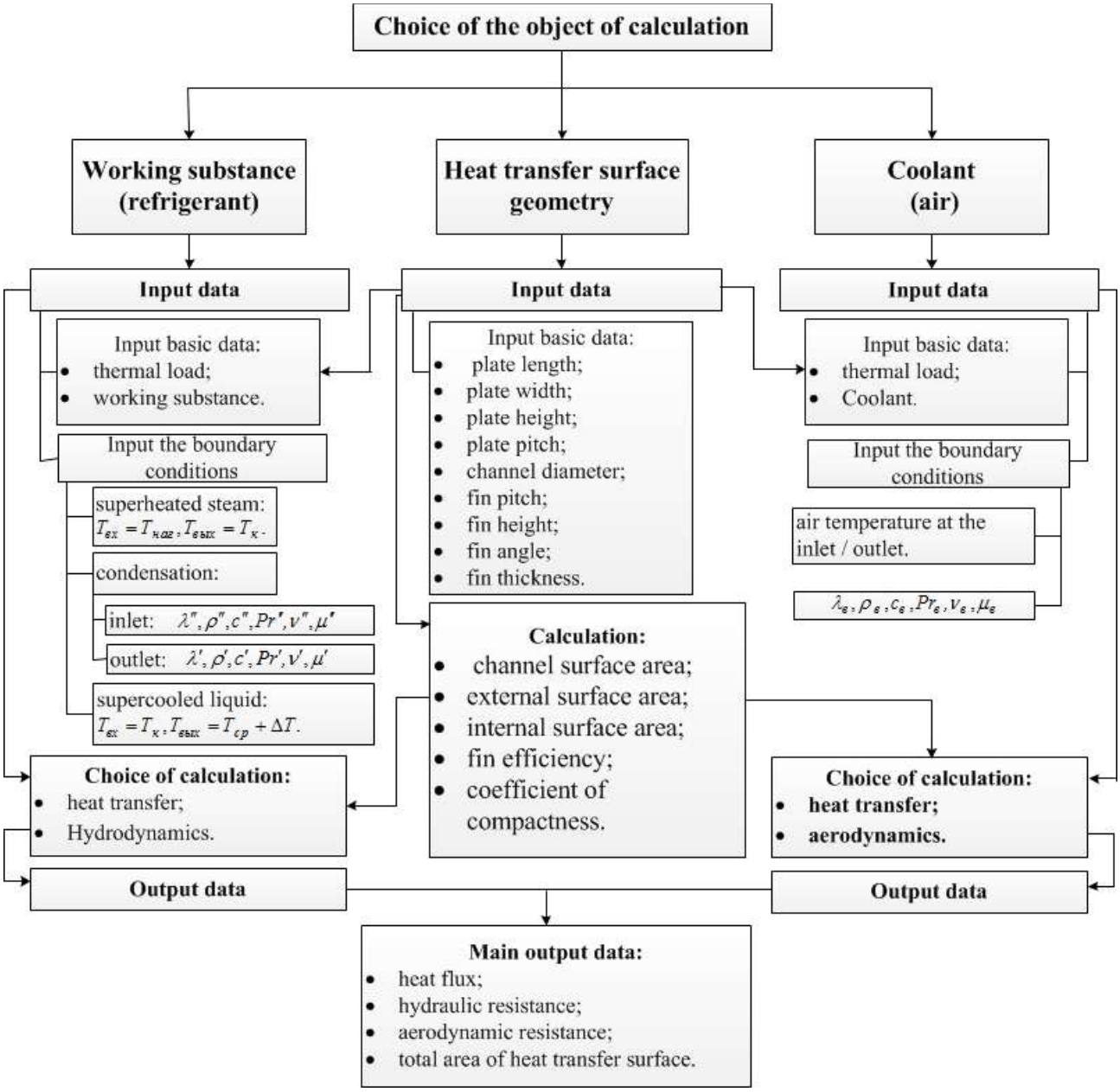

Figure 1 – *Structural diagram*

III. PRACTICAL PART

The authors in [3-8], based on the study a large number of researches in the field of microchannel technology, presented their vision of the engineering calculations of such construction.

A large amount of input parameters, the complex correlation equations for calculating heat transfer, aerodynamics and hydrodynamics, raised the question of necessity to create software for analysis and design of micro-channel heat exchangers. In this regard, by author of this article was developing version of the software calculation of the microchannel air condenser, allowing the use of the proposed software system for masters and post-graduate students research, as well as for the engineers of refrigeration and heat pumps engineering.

Software system by its logical structure is a common calculation of any heat exchanger: the definition of the heat transfer coefficients of the working substance and air, heat flux, two-phase flow resistance of the working substance and the aerodynamic resistance of the air, with access to the size of the heat exchange surface and constructive solutions of the whole apparatus.

During the creation of software package, a number of questions were arised by the methodology of calculation the coefficient of heat transfer and pressure drop as the air side, and on the side of the agent. Therefore, a number of correlation equations with the

design features of microchannel condensers are offered in this software package.

Correlation equations described in [3-8] were selected for expanding calculation options of determination the heat transfer coefficient, pressure drop, heat transfer surfaces.

The microchannel condenser element of heat transfer surface designed as an aluminum plate with circular microchannels, on which the working substance moves. The plates are placed one above the other and connected by weld fins forming channels for the air movement, crossed to the working substance flow. In the considered design of the condenser inside manifold a baffler is located, which serves to provide a two-way movement of the working substance. It is assumed that the first move is the removal of overheating and subsequent condensation, and the second is supercooling of liquid. Thus, the condenser is logically considered a two-way condenser.

The program is based on an object programming method which provides a solution of the problem in terms of objects and operations on them. The condenser is observed as a structure of a set of objects (heat exchange surface geometry, the working substance (refrigerant), coolant (air)), with different parameters (constructive sizes, thermal properties) and the links between them (heat load, the boundary conditions of the processes). Object Pascal was chosen as programming language, Borland Delphi 7 was the programming software package.

Structural diagram of the program is proposed (Figure 1).

Let's present some desktop screenshots on the personal computer with open program. Program contains the four main working windows. A list of working windows for the object "Working substance (refrigerant)" is given as an example: selection of the calculation (Figure 2), the input data (Figure 3), the choice of calculation (Figure 4), output data (Figure 5).

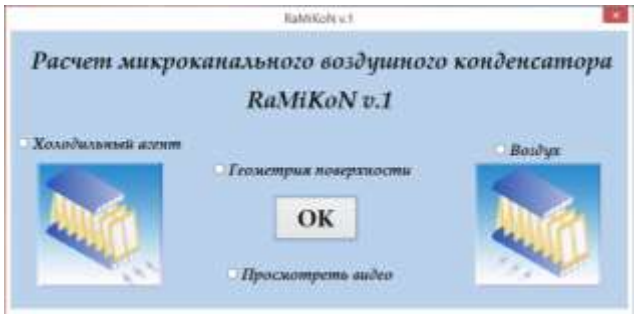

Figure 2 – *Main window*

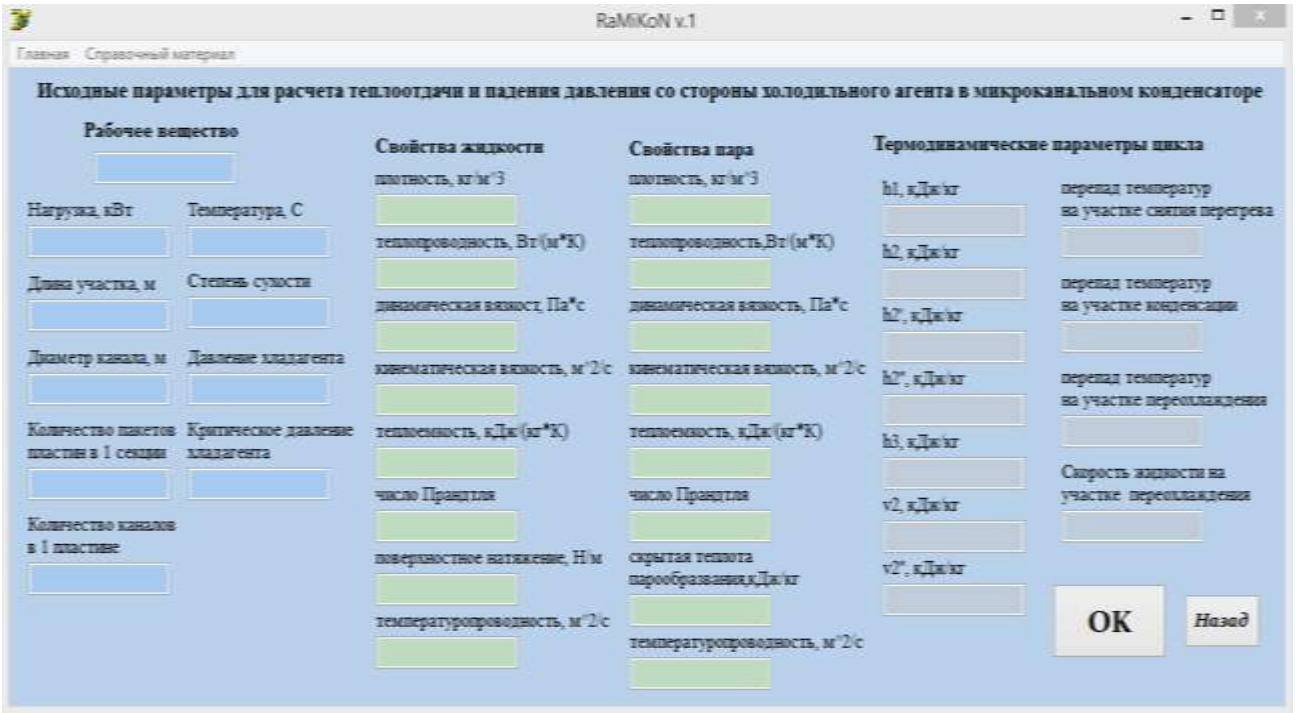

Figure 3 *– Input data for the heat transfer coefficient determination of the agent*

Figure 4 – *The choice of calculation*

Figure 5 – *Output result of calculation the heat transfer coefficient of the agent*

In the window selection of the calculation (Figure 4) there is a list of the main correlation equations for the determination of the heat transfer coefficient of the agent. Each equation is named after the author, accompanied by the conditions of use. The user chooses one of them at his own discretion. As noted earlier, the program provides an opportunity to calculate the equation of different authors, provided that you use the function "Saving the results of calculation", the selected equation allows further comparison of the results obtained in the program. One of the commands of the program is the ability to print the results.

CONCLUSION

Improvement of scientific and methodological approach to designing of microchannel heat exchangers for a wide range of parameters and characteristics of the designed apparatus for further optimization were presented. Created program contains eleven correlation

equations for the heat transfer coefficient and the six equations to determine the pressure drop of the working substance for covering different types of apparatus design and process conditions. A software package for calculating the microchannel air condenser were developed. A content of a large number of calculated dependencies enhances engineers in the selection of the heat exchange surface of the device. The results of the software system will be used in the work of masters, postgraduates.

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КОМП'ЮТЕРНА ПРОГРАМА ДЛЯ РОЗРАХУНКУ МІКРОКАНАЛЬНИХ ТЕПЛООБМІННИКІВ ДЛЯ СИСТЕМ КОНДИЦІОНУВАННЯ ПОВІТРЯ

З метою скорочення часу проектування та проведення багатоваріантних розрахунків розроблено комп'ютерну програму, призначену для розрахунку мікроканальних повітряних конденсаторів. В процесі роботи було використано програмні пакети для визначення теплофізичних властивостей робочого тіла й теплоносія, рівняння кореляції для розрахунку теплообміну, аеродинаміку та гідродинаміку, термодинамічні рівняння для незворотних втрат і їх мінімізації в теплообміннику. Для створення пакету програмного забезпечення використано Borland Delphi *7.*
Ключові слова: *Мікроканальний конденсатор; Теплопередача; Гідродинаміка; Аеродинаміка; Енергоефективність; Незворотність; Техніко-економічний аналіз.*