Automated design, calculation and production of plate heat exchangers for complex cycle gas turbine plants

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Abstract. The comprehensive methodology of computer-aided design and calculation of plate heat exchangers for complex cycle gas turbine plants has been developed. This method allows obtaining a heat exchanger that provides the best thermal and hydraulic characteristics within the specified limits with minimal participation of the designer. The algorithm for closely linking the design stage with the production technology, which makes it possible to obtain a set of 3D models of technological equipment necessary for the producing of a heat exchanger, has been developed. Experimental studies of the heat exchanger produced according to the proposed method showed a close convergence with the calculated data.

1. Introduction
One of the most affordable and effective ways to increase the efficiency of gas turbine plants is the use of heat regeneration. In this case, the efficiency of the plant is significantly affected by the characteristics of the heat exchanger device. In existing designs of gas turbine installations, tubular and plate heat exchangers are used. As practice shows, the use of a plate matrix allows you to achieve optimal heat-hydraulic and dimensional-mass characteristics of the heat exchanger.

2. Problem statement
Many studies have been devoted to the task of developing methods for designing, calculating and producing heat exchangers. The most famous works on the study of heat and hydraulic processes in tubular and plate heat exchangers were carried out by such authors as Savostin, Tikhonov [1], Kays, London [2]. Despite the abundance of works [3-6] devoted to the study of the issue of heat transfer efficiency, the selection of the best geometry of the heat exchange surface for a specific task requires significant material and time expenditures. In addition, the choice of the optimal heat exchange surface is limited by the number of experimental studies conducted by scientists. Thus, in the problem of creating efficient heat exchangers, the issues of optimizing the geometry of the heat exchange surface and their producing technology remain open.

3. Results and discussion
The work is devoted to the development of a comprehensive computer-aided design system for optimal thermal and hydraulic parameters of the plate heat exchanger design and technological equipment for its producing, which provides a significant reduction in material, labor and time costs. The main stages of methodology computer-aided design and calculation of the heat exchanger [3] are shown in figure 1.

Figure 1. Main stages of methodology computer-aided design and calculation of the heat exchanger.

After obtaining the design configuration of the heat exchanger, the characteristics of which suit the engineer, the transition to the technological stage is carried out. Producing technology of the heat exchanger is a problematic task, including working with thin-walled and different-thicknesess parts. The developed technological process for producing the heat exchanger is shown in table 1.

| №  | The name of the operation                                           | Technology equipment                                                               |
|----|-------------------------------------------------------------------|------------------------------------------------------------------------------------|
| 005| Prefoming - getting preforms for the production of heat exchanger plates. | Laser machine with numerical control (NC), power up to 300 W.                      |
| 010| Stamping - receipt of plates by method of the cold sheet metal forming. | The stamp with form-forming elements of the "Frankel packing" type geometry of our own design. |
| 015| Stamping of input channels of plates by plastic deformation method. | A guillotine-type coining device of our own design.                                 |
| 020| Laser cutting of plates into a single size, alignment of end surfaces for subsequent operations. | Laser machine with numerical control (NC), power up to 300 W; forming elements of the stamp for positioning plates. |
| 025| Envelope welding - welding of plates into envelopes.               | Laser machine with numerical control (NC), power up to 300 W; device for clamping welded surfaces of own design. |
| 030| Matrix welding - welding of envelopes into a single heat exchanger matrix | Laser machine with numerical control (NC), power up to 300 W; device for clamping envelopes of our own design; technological inserts for clamping welded surfaces. |
| 035| Laser cutting of heat exchanger casing elements using digital models. | Laser machine with numerical control (NC), power up to 300 W.                      |
| 040| Heat exchanger welding - welding of the matrix with casing parts.  | Laser machine with numerical control (NC), power up to 300 W.                      |
Based on table 1, the technological stage of the comprehensive methodology of computer-aided design, calculation and producing [7] is shown in figure 2.

The comprehensive methodology of computer-aided design, calculation and manufacturing of the heat exchanger allows you to obtain the configuration of plate that provides the best thermal and hydraulic characteristics. According to the presented methodology, the entire set of technology equipment and the experimental heat exchanger were designed and produced.

To verify the comprehensive methodology an experimental plant for studying the heat and hydraulic characteristics of heat exchangers was developed and produced, as shown in figure 3.

The design of the unit provides measurement of the required number of experimental parameters with a minimum number of measuring devices. Thermal insulation of the installation provides losses to the environment of no more than 15 %.

The processed results of the experiment are presented as criteria dependencies in figure 4.
There is a close convergence of the calculation results with experimental data. Data mismatch at high Reynolds numbers does not exceed 5%.

4. Conclusion
The comprehensive methodology of computer-aided design and production of a plate heat exchanger for a complex cycle gas turbine plant has been developed. The methodology allows in automatic mode to obtain the optimal geometry of the heat exchange surface and develop process equipment taking into account the requirements and restrictions set by the designer. Verification of the comprehensive computer-aided design and producing methodology of the plate heat exchanger with experimental and literary sources has shown a close (within the experimental error) convergence of the compared results.

References
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