

Aerodynamic numerical calculations of air-cooled condensers and dry cooling towers at different wind velocities and multilevel configuration of sections

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Abstract. Multilevel configuration of heat exchange sections of air-cooled condensers and dry cooling towers with a multi-row arrangement are offered. Results of a research of the combined operation of fans and V-shaped heat exchangers by methods of numerical model operation at wind and without it for three-row sections are given. It is shown that in the presence of wind multilevel configuration of heat exchange sections has advantages over single-level configuration.

1 Introduction

To make air-cooled condensers (ACC) and dry cooling towers (DCT) compact, when designing them, multi-row arrangement of heat-exchange sections is used. Internal rows of sections work in the inferior conditions that result in nonuniformity of air flow rate through ACC and DCT. Existence of wind creates hindrances for fans and increases nonuniformity of air flow rate [1]. One solution is the multilevel arrangement of sections when some ranks of sections are established at different height.

The purpose of this work is studying processes of the combined operation of the fan and its network (heat exchangers) at wind load capacity and without it for one- and a multilevel arrangement of heat exchange sections, which have V-shaped configuration [2].

2 Calculation models and boundary conditions

For realization of numerical calculations on a basis of the design consisting of three rows of sections in the SOLIDWORKS 3D CAD the corresponding 3D models were created. Two configuration options were considered: single-level, where all three sections are located at one height (fig. 1a) and two-level, where sections 1 and 3 are located above section 2 (fig. 1b).

Aerodynamic calculations of air flow were carried out using the Flow Simulation program, intended for thermal and hydraulic calculations. When performing calculations, it

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was accepted, that in each row are a large number of sections. Calculations were carried out in 2D-statement: in the XY plane, on axis Z the chosen simple size of 1.025 m was set (1/8 from the 3D model size). The numerical model (Fig. 1) represents calculation area with dimensions 35×65×1.025m with three sections and the given boundary conditions for a wind stream.

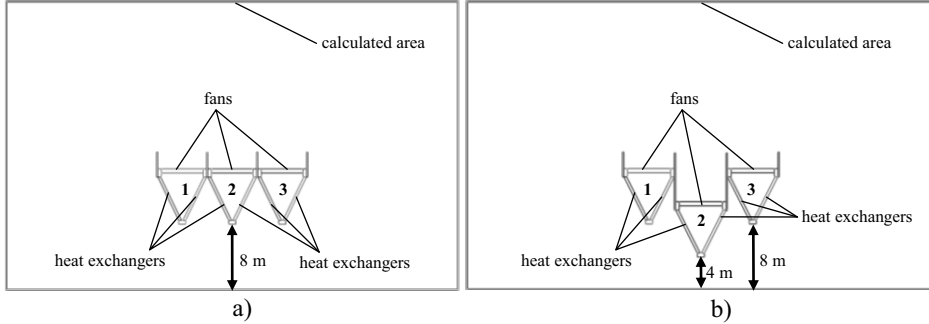


Fig. 1. Calculated model for single-level and two-level configurations of three sections.

Each section includes the fan and two heat exchange modules on which boundary conditions of "the internal fan" and "porous medium" were imposed. The "the internal fan" boundary condition is set by two surfaces imitating an inlet and outlet of the fan. For the fan it is set flow-pressure characteristic according to its model (Fig. 2a). The air stream at the exit of the fan is set without a curling.

The aerodynamic drag of heat exchange modules in the Flow Simulation program is set by a "porous medium" boundary condition, with a transmittivity in the normal direction to it and with the characteristic $\Delta p = f(G)$, where G - is the mass flow, kg/s (fig. 2b). The porous medium in calculation model is presented by parallelepipeds.

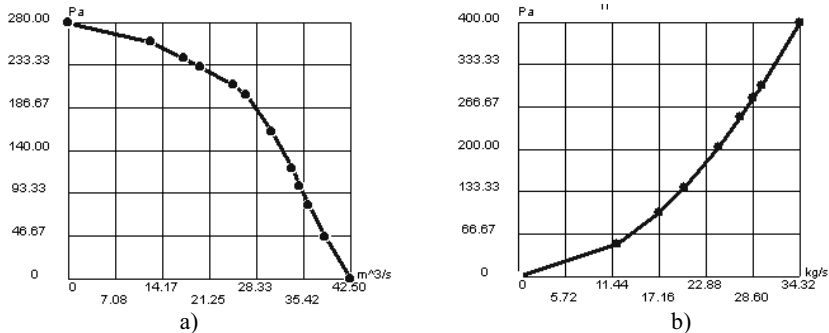


Fig. 2. Flow-pressure characteristic of fan (a) and aerodynamic drag of heat exchanger (b).

For surfaces and volumes, where "the internal fan" and "porous medium" boundary conditions are set, we constructed the initial local grid.

Also the following boundary conditions are set:

- The walls between sections are adiabatic;
- The sizes of calculated area limited to a test area;
- On a lateral face of a test area the normal velocity of a filling wind stream ranges from 0 to 10 m/s, on other sides the size of the static pressure equals to atmospheric (100 kPa;)
- Temperature of the air is 20°C;
- Turbulence model corresponds to k-ε model;
- Flow is both laminar and turbulent, fully developed.

The grid for the calculated model having single-level configuration consists of 506 520 cells; while for multilevel configuration – 509 320 cells.

3 Calculation results

3.1 Streamlines and features of a current of an airflow through sections

For single-level and multilevel configuration of three sections numerical calculations with the wind and without wind were performed. Streamlines are shown in fig. 3-for single-level configuration and in fig. 4-for multilevel configuration.

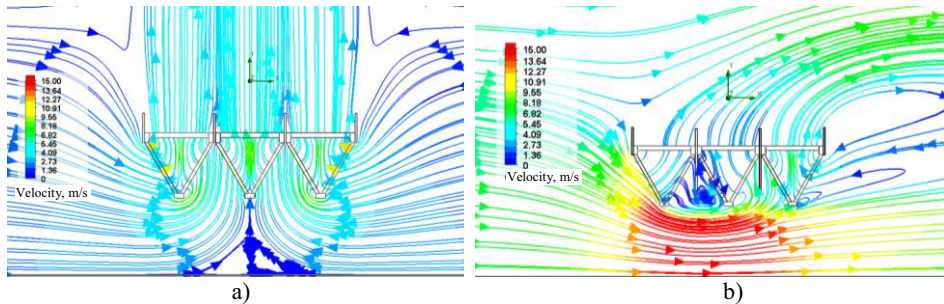


Fig. 3. Streamlines at single-level configuration at wind of 0 m/s (a) and 6 m/s (b).

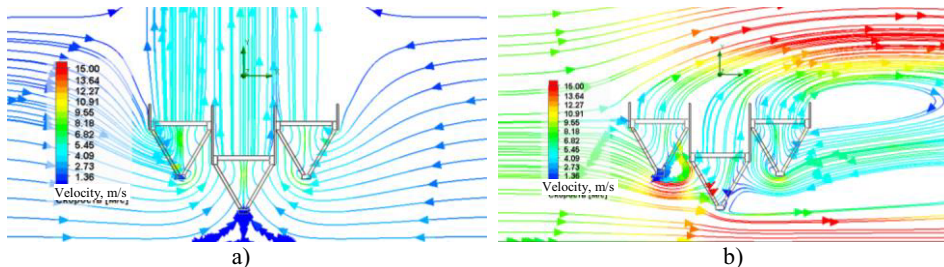


Fig. 4. Streamlines at multilevel configuration at wind of 0 m/s (a) and 10 m/s (b).

3.1.1 Single-level configuration

In the absence of wind we observed the symmetric picture of a flow (Fig. 3a). The larger recirculation zone is formed under wind of 3 m/s on the left heat exchanger of the section 1. Because of emergence of depression field between inlets of sections 1 and 2, air flow rate through them decreases. The summary air flow rate decreases by 20% in comparison with a flow rate in the absence of wind. With increase wind velocity up to 6 m/s (fig. 3b) the recirculation on section 1 disappears, however less intensive flow appears in section 3. The depression field at the inlet between sections 1 and 2 increases. The air flow direction in the right heat exchanger of section 1 is reversed. The summary air flow rate decreases by 35%.

3.1.2 Multi-level configuration

At a velocity of wind of 3 m/s in the section 1 there is also a recirculation zone, however, less intensive, than at single-level configuration. The summary air flow rate decreases by 13%. With increase in wind velocity up to 10 m/s the recirculation zone in section 1

disappears (Fig. 4b). In the absence of wind, summary air flow rate having reached a minimum at 3-4 m/s, increases to 92.5%.

3.2 Generalization of results of research

As a result of calculations, we have obtained mass flows on fans in the sections in the presence and absence of wind, which are presented in Table 1.

Table 1. Mass flows through all fans of sections at a different velocity of wind.

Velocity of wind, m/s	Mass flows through all fans, kg/s	
	single-level	multilevel
0	113.3	113.7
3	89.71	98.86
6	74.20	—
8	—	103.11
10	—	105.11

Based on the results obtained, we constructed the dependence of mass flow through sections on wind velocity, shown in Fig. 5.

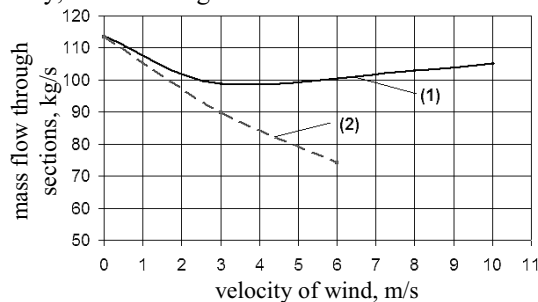


Fig. 5. Dependence of mass flow of air on wind velocity through sections for multilevel (1) and single-level (2) configurations.

The results show that a multilevel configuration is preferable as compared to a one-level configuration when developing ACC and DCT under continuous wind impact.

3 Conclusion

The executed numerical simulation showed the existence of positive effect of multilevel sections configuration:

- More uniform distribution of air flow rates in multilevel sections as compared to single-level configuration;
- Increase air flow rate through multilevel sections when increasing wind velocity.

References

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2. O.O. Milman, V.A. Fedorov, *Air-Condensation Plants*, (MEI, Moscow, 2002) [in Russian]