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Results from Experimental Investigations of the Performance of Air Condensers for Steam Turbine Units

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Abstract—Results from experimental investigations of the model versions of Type ABC GI air condensers are presented, and it is shown that these condensers have better performance characteristics as compared with their analogs that are currently in operation.

Keywords: air condenser, condensation, heat transfer, noise, vibration

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Air-cooled heat exchangers used in steam turbine units serve for condensing spent steam. Despite their having bulky sizes and high cost as compared with water-cooled condensers, they are the only possible choice in regions lacking sufficient sources of service cooling water. Shortage of water (or too high cost of water) is also faced in megapolices; in some cases, emissions of water into the atmosphere are prohibited due to environmental limitations [1]: it has been found that emissions of steam into the atmosphere are among the factors causing the greenhouse effect.

Different heat removal schemes with the use of air-cooled apparatuses were subjected to a thermodynamic analysis [2, 3], and it was shown that the most energy-efficient technology involves the use of air-cooled condensers (ACs) spent steam in which condenses directly inside the condenser tubes.

The list of main factors determining the parameters of an AC with the specified geometrical characteristics includes the following ones:

—the so-called header effect, which influences the flowrates of steam entering into the heat-transfer modules;

—air flow velocity in the shell space and its humidity;

—cooling air temperature at the inlet to the tube bundle and at the outlet from it;

—the way in which the flow of condensing steam is organized inside the tubes;

—steam flowrate (thermal power);

—presence of zones in the heat-transfer surface that are filled with steam–gas mixture with high concentration of nondensables;

—the characteristic of the gas removal unit;

—the flowrate of nondensables entering into the condenser; and

—wind velocity and its direction.

Experience gained from operation of ACs indicates that their real heat-transfer coefficient is lower than its design values. This is attributed to the fact that part of heat-transfer tubes is filled with steam–air mixture with high concentration of air, due to which its is excluded from the heat removal process almost completely [4].

Calculation studies performed using the software systems PHOENICS, Flow Vision, ANSYS, and ANES that were carried out by teams of specialists from the Moscow Power Engineering Institute (MPEI), Bauman Moscow State Technical University (BMSTU), and the CHAM Co. (England) also failed to take into account the real physical processes occurring inside air condensers. For clarifying these processes, an experimental rig for testing model air condensers has been constructed at the interdepartmental research laboratory (IDRL), and comprehensive investigations of their thermal-hydraulic and acoustical characteristics have been carried out.[1]

The experimental rig's process circuit is shown in Fig. 1. Its main components include a steam boiler (T_0 = 560°C, p_0 = 3.3 MPa), a dampening throttle device, and three model air condensers. Pressures and pressure differences were measured using Type AIR sensors; temperatures were measured using thermocouples and resistance temperature detectors; vibration and noise characteristics were measured using instruments produced by Bruel&Kjaer; and flowrates of nondensables were measured by rotameter. The velocity fields of cold air were determined using EE575 sensors. Pressure differences across the heat-transfer

[1] This laboratory was established following an agreement between the Kaluga region Government, Moscow State University, BMSTU, Kaluga Branch of BMSTU, SPC Turbocon, and UNIKHIMTEK by a request from the Ministry of Education and Science of Russian Federation.