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„THERMODYNAMIC ANALYSIS OF INTENSIFICATION METHODS OF ADSORPTION DEHUMIDIFICATION IN AIR-CONDITIONING"

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Abstract:

During last three decades, the international agreements aiming to reduce the ozone layer depletion and slow down global warming led to considerable limitations in application of hydrocarbon-based refrigerants CFC, HCFC and HFC. Moreover, the global increase of cooling demand has been reported in literature due to climate changes and increasing availability of cooling technologies. Abovementioned factors triggered the development of alternative cooling technologies. Another challenge is related to effective utilization of district heating generated in Combined Heat and Power (CHP) plants. This heat is currently useless during the summer period. In Poland around 20% of electric energy is generated in CHP plants. Therefore part of R&D work is focused on thermally driven cooling technologies, especially those able to utilize low-temperature heat.

The adsorption of water vapor by silica gel enables the conversion into cold of heat as low as 50°C. This phenomenon is applied in adsorption chillers working under sub pressure and by so called Desiccant Coolers (DC). The working fluid of DC is humid air which is firstly desiccated and afterwards again humidified. The challenge of adsorption-based cooling technologies is intensification of heat and mass transfer processes in the adsorption bed, what influences the performance, size and price of adsorption chillers. Fluidized beds seem to be promising alternative to current adsorption beds. Chaotic movement of particles in fluidized bed intensify heat and mass transfer processes.

Carried literature review has shown that the phenomenon of water-silica gel adsorption in fluidized bed is still insufficiently investigated. There is not enough experimental data, reliable modelling methods and optimization analyzes.

The thesis aims to analyze the factors enabling intensification of air desiccation processes based on adsorption especially by carrying experimental survey, developing modelling method and, based on developed model, carrying theoretical optimization analyzes.

In order to carry experimental survey the test stand was designed and built in Laboratory of Thermodynamics at the Department of Mechanical and Power Engineering of Wroclaw University of Science and Technology. The experimental research was carried for desiccant particle diameters ranging from 0,6 to 5 mm, air temperatures from 20 to 30 °C for adsorption and from 50 to 70 °C for desorption, superficial air velocities ranging from 2 to 6 m/s and desiccant filling height from 2 to 10 cm.

Carried experimental survey enables to formulate modelling assumptions concerning dominating mass transfer mechanisms during adsorption and desorption in fluidized bed. The developed model was implemented in PYTHON and verified with the experimental data. The model enabled to carry the theoretical optimization studies.

Two analyzes have been carried out. First analysis aimed to determine the influence of operating parameters such as desiccant particle diameter, superficial air velocities, bed switching time and desiccant filling height on adsorption and desorption characteristics and performance of fluidized adsorption chiller. As a result the rational ranges of operating

parameters were determined what enables the increase of performance of fluidised desiccant coolers. Second study, based on exergy analysis, aimed to point out the main exergy destruction sources and assess the possibility of reduction of these losses.

Moreover, potential methods of further intensification of air desiccation via adsorption were proposed: desiccant particle shape modification and application of multibed systems. The theoretical analysis of impact of desiccant particle shape modification shows considerable potential of this method to increase SCP and electric COP. The analysis of patented multibed adsorption air dryer shows the potential of electric COP increase and improvement of air desiccation.

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