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OPTIMIZATION OF MODES OF OPERATION INDUSTRIAL HVAC SYSTEM

In this work elaborates model of heating, ventilation and air conditioning (HVAC) system, carry out simulation of different modes of operating, assessment and optimization of consumption electric energy. Develop recommendations in exploitation of such systems.

Keywords: *heating, ventilation, conditioning, HVAC systems, optimization of modes of operation, energy saving, energy efficiency.*

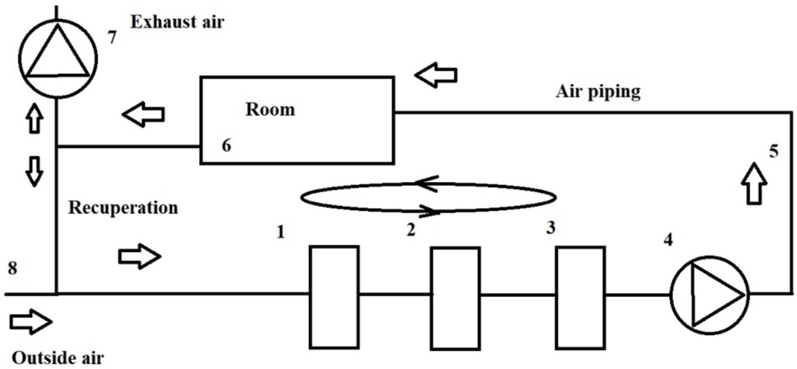
В цій роботі розробляється та досліджується модель системи СВіК (системи вентиляції та кондиціонування), проводиться симуляція різних режимів роботи установки, оцінка та оптимізація споживання електроенергії. Надаються рекомендації по експлуатації такої системи.

Ключові слова: *вентиляція, кондиціонування, оптимізація режимів роботи, енергозбереження, енергоефективність.*

В этой работе разрабатывается и исследуется модель системы СВиК (системы вентиляции и кондиционирования), проводится симуляция различных режимов работы установки, оценка и оптимизация потребления электроэнергии. Даются рекомендации по эксплуатации такой системы.

Ключевые слова: *вентиляция, кондиционирование, оптимизация режимов работы, энергосбережение, энергоэффективность.*

This work consider HVAC system, development from system a model which basically can be described by internal elements like fan, heater, air piping and etc. Also it will be found new strategies to achieve optimal regulation for such system, which allow to confirm the best decision depending on multivariable changing dynamic model. Developed model introduce evaluation [1] and prediction [2] of parameters of external environment like temperature. Simple HVAC model can be shown on picture 1.



Picture 1 **Simple block diagram of HVAC system**

If we assume that in room (pic.1.6) present some source of pollution (p) with mass flow rate like generation $\dot{m}_{\mathrm{p,g}}$ and air in room is homogeneous mixture we have such equation (1) for mass balance of pollutant:

$$\frac{dm_{\mathrm{p}}}{dt} = m_{\mathrm{p,in}} - m_{\mathrm{p,out}} + \dot{m}_{\mathrm{p,g}} \qquad (1)$$

where m_{p} - mass of pollutant in room, kg;

$\dot{m}_{\mathrm{p,in}}$ - inflow air with some amount of pollutant due to recuperation, kg/s;

$\dot{m}_{\mathrm{p,out}}$ - effluent air with pollutant, ks/s;

$\dot{m}_{\mathrm{p,g}}$ - generation of pollutant in air in room, kg/s.

Also mass balance law for pollutant can be rewritten in terms of parameter of air:

$$\frac{dm_{\mathrm{p}}}{dt} = \dot{V}_{\mathrm{air}} \cdot (c_{\mathrm{p,in}} - c_{\mathrm{p,out}}) + \dot{m}_{\mathrm{p,g}} \qquad (2)$$

where $\dot{V}_{\mathrm{air}}$ - inflow volume of air in room, m3/s;

$c_{\mathrm{p,in}}$ - concentration of pollutant in inflow air, kg/m3 of pure air;

$c_{\mathrm{p,out}}$ - concentration of pollutant in effluent air, kg/m3 of pure air.

First element on block diagram is heater (pic.1.1), which main equation (3) for description is heat flow by convection:

$$\dot{Q}_{\mathrm{H}} = \frac{dH_{\mathrm{air}}}{dt} = c_{\mathrm{air}}\dot{m}_{\mathrm{air}}\left(t_{\mathrm{out}} - t_{\mathrm{in}}\right) = \alpha_{\mathrm{HE}}(t_{\mathrm{tube}} - t_{\mathrm{in}})A_{\mathrm{HE}} \qquad (3)$$

where $\dot{Q}_{\mathrm{H}}$ - heat transfer by heat exchanger, kW;

H_{air} - enthalpy of air at selected moment of time, kJ;

c_{air} - heat capacity of air, kJ/kg;

$\dot{m}_{\mathrm{air}}$ - mass flow of air in heat exchanger and out, kg/s;

t_{out}, t_{in} - inflow and outflow temperature of air, ◌̊C;

α_{HE} - heat transfer coefficient for convection, kW/(◌̊C m2);

A_{HE} - heat transfer area of heat exchanger, m2.

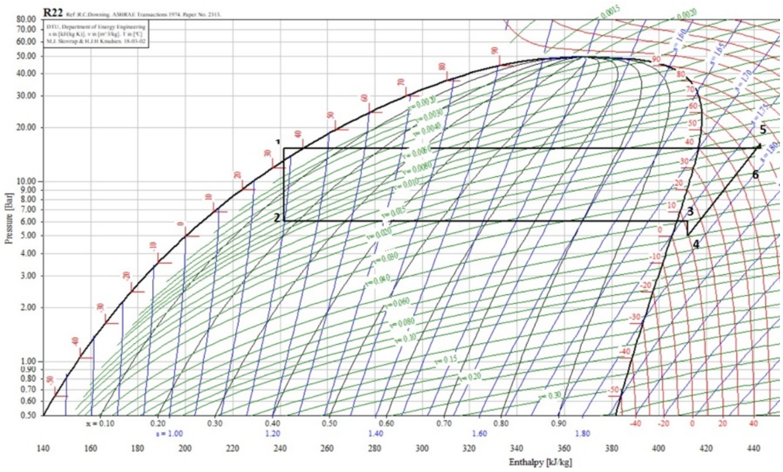
Second part of model is cooling device or refrigerator (pic.1.2) also with heat exchanger and be described by cooling cycle (picture 2). For model description was taken R22 as the most common agent for cooling with equation for description:

$$\dot{Q}_{\mathrm{C}} = \dot{m}_{\mathrm{R22}} \cdot \varepsilon \cdot W \qquad (4)$$

where $\dot{Q}_{\mathrm{C}}$ - heat flow of cooling the air in heat exchanger of cooling device, kW;

$\dot{m}_{\mathrm{R22}}$ - mass flow of cooling agent due to work of compressor, kg/s;

ε - cooling coefficient;
W - specific work of compressor, kJ/kg.



Picture 2 **Cooling cycle of air cooling device**

Parameters of fan (5) can be described as approximated function of 2nd order:

$$p_{\text{dyn}}, p_{\text{st}}, \eta = f(\dot{V}_{\text{air}}) \approx a_0 + a_1 \dot{V}_{\text{air}} + a_2 \dot{V}_{\text{air}}^2 \quad (5)$$

In this paper, we have addressed the modelling and optimization problem of a central cooling plant to target energy savings and verified the proposed approach [3]. By using the monitored data, mathematical models for the set-up components are developed and implemented in a transient simulation program in order to predict the performance of the integrated system operating in various conditions. Results showed that by applying this approach, an air-cooled central cooling plant HVAC system can achieve significant improvements in energy-efficiency and performance, especially in part-load conditions.

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