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EXERGY EFFECTIVE REGIMES OF EXPLOITATION OF AIR SPLIT-CONDITIONERS OF FIRM “LG”

The elaborating method of the exergetic analysis of air split-conditioners one-step Freon refrigeration machines was used in this article. The dependence of exergetic output-input ratio for refrigeration machine of air split-conditioner of firm “LG” with cooling capacity 3666 W for refrigerators agent R22 from air flow rates on the evaporator by different external temperature regimes was defined.

Key words: exergy, balance, air conditioner, air flow rate, efficiency.

Використано розроблений ексергетичний метод аналізу роботи одноступеневих хладонових холодильних машин split-кондиціонерів. Встановлено залежність ексергетичного ККД split-кондиціонера фірми “LG” холодопродуктивністю 3666 Вт на холодильному агенті R22 від витрат повітря на випарнику для різних зовнішніх температурних режимів.

Ключові слова: ексергія, баланс, кондиціонер, витрата повітря, ефективність.

Resolution of the problem.

Refrigeration machines, that are used in air split-conditioners, needs right choice of energy efficient modes of their operation, the establishment of which is possible by using exergetic method of analysis of their work [1, 2, 3].

As a rule, manufacturers of air split-conditioners provide their exploitation at various air flow rates on the evaporator. But, unfortunately, none manufacturer gives recommendations which air flow rate should be used depending on external temperature conditions.

Analysis of recent researches and publications

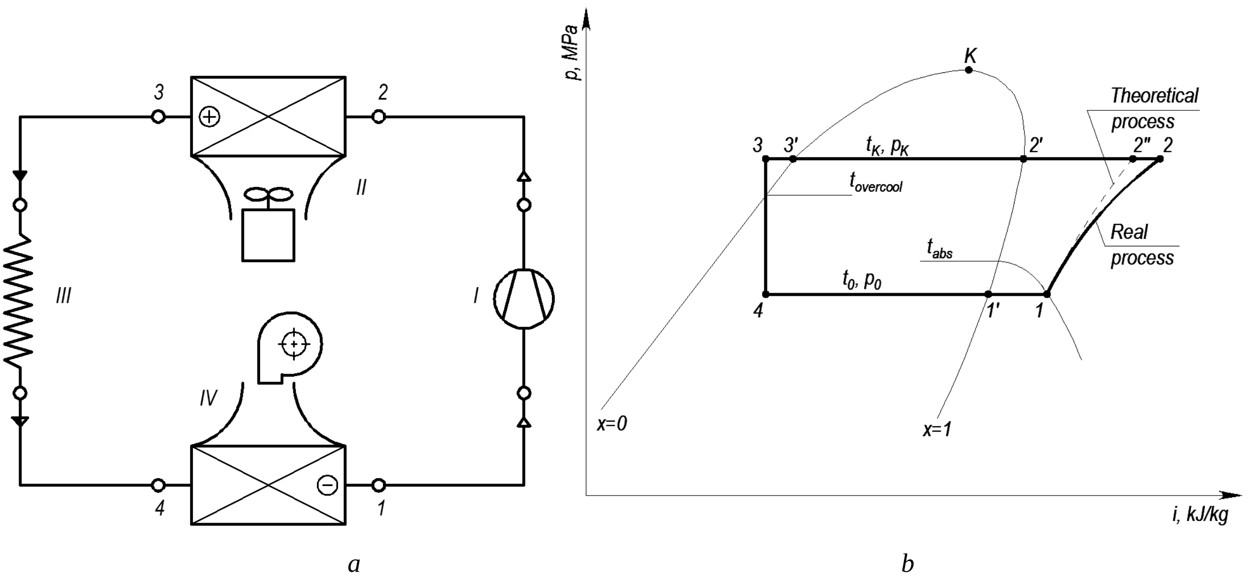
The exergetic analysis of one-step refrigeration machines most detailed presented in [1], which is unapplied for air split-conditioners refrigeration machines, in which the evaporator and condenser are washing by appropriate air, while in contour of refrigeration machine another refrigerant is circulating. Also, this method of analysis is brief highlighted in [2, 3].

That’s why the exergetic method of analysis of air split-conditioners refrigeration machines was elaborated (pic. 1) which is the method of thermodynamic study of refrigeration machine as a whole, and its individual parts, to get full information about the processes of energy transformation that occur in such systems [4, 5]. The result of the analysis is to find the exergetic output-input ratio, which indicates about the energy efficiency of air split-conditioner’s regimes of exploitation.

The goal of the work – to find energy efficient air flow rate on the evaporator of air split-conditioners refrigeration machines by different external temperature regimes of operation, where we will have the highest exergetic output-input ratio, which is mean there will be energy efficient mode of conditioner’s regimes of exploitation.

To do this, the following should be identified:

exergetic output-input ratio, for example, for air split-conditioner of firm “LG” with standard cooling capacity 3666 W by different external temperature regimes of exploitation and air flow rates on the evaporator. And it was the task of researches.



Pic. 1. The refrigeration machines fundamental scheme (a)
and construction the processes of its work on p,i-diagram (b):
I – compressor; II – condenser; III – capillary tube (throttle); IV – evaporator
1, 2, 3, 4 – characteristic points of the refrigeration cycle

The statement of main material.

The exergetic output-input ratio η_e of air split-conditioners one-step Freon refrigeration machines was determined from its *exergetic balance* for 1 kg/s consumption of circulating working refrigerators agent, which is:

$$e_{in} = e_{out} + \Sigma d \text{ , kJ/kg,} \quad (1)$$

where $e_{in} = l = e_{out}^{comp}$ – input unit exergy flow in the air conditioner compressor (unit work of compressor), kJ/kg; $e_{out} = e_{evap}^{air}$ – output unit exergy flow from the evaporator of air conditioner or exergetic unit air conditioner cooling capacity, kJ/kg; Σd – total unit exergy flow losses in all the apparatus of air split-conditioners refrigeration machines, kJ/kg.

On this basis, the *exergetic output-input ratio* η_e was determined as follows:

$$\eta_e = \frac{e_{out}}{e_{in}} = 1 - \frac{\Sigma d}{e_{in}} . \quad (2)$$

The elaborating computer program of exergetic analysis of air split-conditioners refrigerator machine *without effective compressors cooling* was used for researches.

Technical characteristics of chosen to study air split-conditioner "LG" by standard external temperature regime t_{H_1} = +35°C i t_{C_1} = +27°C: cooling capacity Q_c^{st} = 3666 W, consumed power N_{cons}^{st} = 1370 W, amount of condensate W_{cond}^{st} = 1,5 L/h, air flow rates on the evaporator L_{evap}^{st} = 510 m^3/h and condenser L_c^{st} = 1500 m^3/h of conditioner and, accordingly, the exergetic output-input ratio η_e = 0,2177, refrigerators agent Freon-22 (R22).

To define the exergetic output-input ratio of the selected conditioner by different working external temperatures regimes of exploitation and air flow rates on the evaporator were accepted the following input data:

– the operating temperature of the environment $22 \le t_{H_1} \le 40$°C (external temperature of air);
– the operating internal (recirculating) temperature of air according to the environment temperature $20 \le t_{C_1} \le 29$°C;

– air flow rate on the evaporator L_{evap} = 510, 440 i 380 m^3/h;
– air flow rate on the condenser L_c = 1500 m^3/h;
– the finite temperature difference in the evaporator (internal air at the outlet of the evaporator and boiling refrigerators agent) Δt_{evap} = 2,8°C;
– the finite temperature difference in condenser (refrigerant, which condenses and external air at the outlet of the condenser) Δt_c = 4,2°C;
– overheating temperature difference in the evaporator $\Delta t_{overheat}$ = 10°C;
– overcooling temperature difference in the condenser $\Delta t_{overcool}$ = 5°C;
– adiabatic (indicator) output-input ratio for compressor η_i = 0,8;
– electromechanical output-input ratio for compressor $\eta_{ем}$ = 0,9;
– refrigerators agent – Freon-22 (R22);
– fundamental scheme of the refrigeration unit and work processes in it (pic. 1).

The results obtained during the analysis are summarized in the table (technical characteristics of air conditioner by standard external temperature regime are specified *in italics*, **bold** – operating external air temperatures and energy efficient for them air flow rates on the evaporator).

Table 1

The research results of dependence exergetic output-input ratiofor air split-conditioner of firm "LG" with cooling capacity 3666 W from external0 air temperature and air flow rates on the evaporator

t_{H_1}, °C	t_{C_1}, °C	L_{evap}, m^3/h	Q_c^{oper}, W	N_{cons}, W	W_{cond}^{oper}, L/h	η_e
35	*27*	*510*	*3666*	*1370*	*1,50*	*0,2177*
—"—	—"—	*440*	—"—	—"—	—"—	*0,2188*
—"—	—"—	***380***	—"—	—"—	—"—	***0,2197***
22	20	510	3721	1391	1,87	0,1631
—"—	—"—	440	—"—	—"—	—"—	0,1704
—"—	—"—	**380**	—"—	—"—	—"—	**0,1774**
25	22	510	3758	1404	1,76	0,1752
—"—	—"—	440	—"—	—"—	—"—	0,1811
—"—	—"—	**380**	—"—	—"—	—"—	**0,1857**
28	24	510	3794	1418	1,66	0,1853
—"—	—"—	440	—"—	—"—	—"—	0,1899
—"—	—"—	**380**	—"—	—"—	—"—	**0,1943**
31	26	510	3831	1432	1,55	0,1935
—"—	—"—	440	—"—	—"—	—"—	0,1970
—"—	—"—	**380**	—"—	—"—	—"—	**0,2002**
34	27	510	3739	1397	1,50	0,2096
—"—	—"—	440	—"—	—"—	—"—	0,2114
—"—	—"—	**380**	—"—	—"—	—"—	**0,2130**
37	28	510	3648	1363	1,45	0,2235
—"—	—"—	440	—"—	—"—	—"—	0,2239
—"—	—"—	**380**	—"—	—"—	—"—	**0,2241**
38	28	**510**	3574	1336	1,45	**0,2308**
—"—	—"—	440	—"—	—"—	—"—	0,2307
—"—	—"—	380	—"—	—"—	—"—	0,2302
40	29	**510**	3556	1329	1,40	**0,2353**
—"—	—"—	440	—"—	—"—	—"—	0,2346
—"—	—"—	380	—"—	—"—	—"—	0,2336

Summary

Analyzing the data in the table, the following conclusions can be reached. Energy efficient exploitation of selected conditioners refrigeration machine with higher exergetic output-input ratio is required to apply to external air temperature $t_{H_1} \leq$ 37°C lower air flow rate on its evaporator L_{evap} = 380 m^3/h, then for 37 $< t_{H_1} \leq$ 40°C – higher flow rate L_{evap} = 510 m^3/h. This means, that it is desirable for energy efficient exploitation of any air split-conditioner to previously make the exergic analysis of its refrigeration machine's work.

So, conducted the exergic analysis of selected conditioners refrigeration machine's work by different operating external temperature regimes of exploitation and air flow rates on the evaporator showed that for its energy efficient exploitation with higher exergetic output-input ratio there is a need that for higher external temperatures should be used higher air flow rates on the evaporator of air conditioner. This is quite consistent with the principles of maintaining the microclimate indoors, when higher internal air temperatures must comply higher air mobility. This means, that manufacturing company should apply the exergetic analysis of its conditioners and accordingly recommend their energy efficient exploitation. These researches are proposed to introduce PF «Systems of condition and ventilation» і PF «Dominanta–Eco» (t. Lviv), Ladyzhynska and Dobrotvirska HES, which allowed them to reduce electricity consumption in exploited air split-conditioners refrigeration machines depending on external temperature regimes at 7-18% (with implementation acts on it).

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