CONTROL OF AIR CONSUMPTION FOR THE VENTILATION OF PRODUCTION PREMISES

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ABSTRACT

The improvement of air quality due to self-restricted air consumption in regions as well as globally appears to have considerable promise. Self-restriction means the normalized air (energy) consumption reasonable for favourable conditions of life and work. It will allow to use the compensation concept when the consumption is higher than normal. This method enables to select environment-friendly means of energy production as well as of its consumption taking into account the peculiarities of regions.

Energy is a vital force of the human society and the generation of energy under modern conditions is inseparably linked with the air consumption. The growth of living standards involves higher energy requirements and a wider use of fuel and hydropower. This leads to a direct damage not only to forests, rivers, lakes, but also to the Earth's atmosphere. The energy consumption per capita is growing and forecasts show that it will be 4 times as high in the next 50 years. Mineral organic fuel accounts for 80% of the world energy resources and one half of this amount is consumed by transport the growth of which exceeds the growth of population. The combustion of organic fuel causes emission of contaminants which by 50% consist of the carbon dioxide known to lead to the greenhouse effect, by 20% of carbon fluorides and chlorides and by 20% of methane. 25 billion tons of carbon dioxide is annually emitted into the atmosphere, with the US and Russia producing 5 and 1.7 billion tons respectively.

Table 1. Greenhouse gas emission factors of various energy sources g CO_2 equiv./kWh(e).

	Hard coal	Oil	Natural gas	Nuclear	Hydro	Solar PV	Wind
Uchiyama	990	686		21	18	123	120
Yasukawa	1213			25,7			
Friedrich	1290			19		279	16
Dones	1020	890	772	24	4	130	

The industrially developed countries are most responsible for carbon dioxide emissions. he energy consumption growth in developing countries will further aggravate the ecological situation. China and India (where one third of the world's population lives) alone plan respectively to double and treble the production of coal by 2005. Therefore, limitation of energy generation from conventional sources – mineral organic fuels – and transition to alternative sources is one of the main objectives. One of such sources is nuclear energy the development of which will allow to limit the use of organic fuel in the next 50 years. By

Table 2

Energy and air consumption for power production in the year in the world

Year	Conditional fuel consumption, 10^9 t	Produced power			Air consumption	Number of population, 10^9 man	Specific energy consumption, kW*year/man	Specific air consumption, 10^3 m^3/man.	Specific air consumption, t/man
		10^{17} kJ	10^{13} kW*h	10^9 kW*year					
1970	7	2,05	5.70	6,50	5,6	3,1	2.10	18.1	23.3
1975	9	2,64	7,34	8.38	7.2	3.9	2.30	18.2	23.5
1980	11	3.22	8.95	1,02	8,8	4.0	2.55	22,0	28,4
2000	27	8,03	22,3	25,4	22,0	6.4	4.00	34,4	44,4
2020	54	15,8	44,0	50,2	43,0	8.8	5,80	48,9	63,1

comparison with other energy sources, organic fuels feature incommensurably high carbon dioxide emissions per energy unit (see table 1).

At the same time, the world energy consumption development (see table 2) demonstrates that modern society tends largely to use conventional energy sources and consume energy, as rule, in an extensive way. It's no wonder the world community is facing the problem of reducing the carbon dioxide emissions by 20% by the year 2005 and by 50% by the year 2050. A considerable portion of the total amount of consumed energy is connected with ventilation, which includes not only the use of air for creation of a safe atmosphere but also conveyance and heat treatment of air. In USSR, consumption of energy and, consequently, indirect consumption of air accounted on the whole for approximately 15% of the total energy produced in the country in 1990. These expenditures were incomparably higher at a number of enterprises, which is connected firstly with the widespread opinion about the cheapness of energy and heat, secondly with the remaining tendencies to design ventilation facilities based on more than two-decades-old concepts and, thirdly, with the fact that the overwhelming majority of existing production premises was designed and built 15-20 or more years ago.

Table 3. Specific energy consumption for air transport and heating ($W*h/m^3$)

Plant	Ventilation	Transport (T)	Heating (H)	H/T ratio
B	Supply	0,74	7,38	10,0
	Exhaust:			
	General	1,13		
	Local	1,45		
	Total	1,71	4,3	
C	Supply	0,55	7,40	13,4
	Exhaust:			
	General	0,87		
	Local	0,80		
	Total	1,05	7,1	

The data presented in table 3 characterize specific energy expenditures with respect to different ventilation elements. From the data provided in table 3 it is evident that energy expenditures in ventilation systems are primarily connected with the heating of air and are 5-7 times as high as the aggregate expenditures on the conveyance of incoming and outgoing air. This determines one of the methods of reduction in the air consumption and increase in the efficiency of its use. It is well known [1] that in the middle belt of Russia the heating of 1000 m^3 of outer air supplied to the premises operating in two shifts during the heating season requires some 4 tonnes of reference fuel. With the market price of coal being 270-350 rubles a tonne, one cubic metre of air costs more than one ruble in winter.

Thus, it is advisable that air consumption should be minimized wherever possible and the thermal energy expended for heating it should be reused. In other words, it is advisable to regulate the air consumption according to time and reuse it wherever possible. Recirculating ventilation is one of the means of doing it. Recirculating ventilation systems may be of different modifications and sizes, but all of them primarily require safe quality of air as well as effective and economic application. Thus, in the absence of emissions of admixtures into the air of production premises, the volume of fresh air supplied to the recirculation system should be determined so as to liquidate the excess heat produced as the result of technological process, people's activity or other sources

$$L_1 = \frac{G_T / C_p\rho - (1 - 1/\xi)\, t_e L_r}{t_e - t_1}, \qquad (1)$$

where G_T is the intensity of the source of heat emission, W; C_P is the specific heat of air, J/kg °C; ρ is its density, kg/m^3; $\xi = t_e / t_r$ is the coefficient of reduction in the temperature of the removed air (t_e); t_r is the temperature of the air returned via the recirculation chain; $t_1$is the temperature of the incoming air, °C; L_r is the air expenditure for the recirculation chain, m^3/s.

Where admixtures are emitted, the quantity of the air used for ventilation is the sum of the incoming and recirculating air

$$L = L_1 + L_r \qquad (2)$$

In this case, the quantity of the recirculating air is determined as

$$L_r = \frac{K_r * g}{C_Д\,[1 - K_r * (1-n)] - C_1(1-K_r)}, \qquad (3)$$

where K_r is the accepted recirculation coefficient; g is the amount of admixtures emitted in a unit of time; $C_Д$ is the concentration of admixtures acceptable by sanitary rules; C_1 is the concentration of admixtures in the incoming air; n is the coefficient of air purification in the recirculation system

$$n = \frac{Co}{C_r}, \qquad (4)$$

where Co is the concentration of admixtures after the air purification in the recirculation system; C_r is the concentration of admixtures in the air removed or supplied to the recirculation system.

Figure 1 shows various scenarios of alteration of the expenditure of the air used for ventilation, with various recirculation coefficients. It is evident from examination of the data provided in fig.1 that recirculation allows to reduce emissions of admixtures into the atmosphere, reduces the heating of incoming air. As the recirculation coefficient increases, the total amount of the air used for ventilation reduces and, where partially polluted air is used, the volume of the air used for ventilation is less than in the case of single-pass ventilation.

It is known that from the standpoint of microclimate the environment which can keep the man in comfort through sensor channels is the most favorable for him. An even air temperature is undesirable for the man because it leads to weakening of the organism's resistibility. The microclimate must pulse in order to train thermoreceptors [2]. Firstly, this strengthens the human organism, secondly, helps to increase the productivity of labour and, thirdly, reduces the expenditure of energy on the heating of incoming air. Calculations show that periodical temperature reduction by 3 degrees saves up to 5% of fuel.

Alongside reduction in the quantity of incoming and outgoing air and control of the microclimate characteristics in the working zone, it is also advisable to save energy in the ventilation systems by using secondary industrial thermal energy resources and the heat of the removed air. In the pre-reform period, when the Soviet industry consumed 700 million tonnes of reference fuel per year in the form of direct fuel combustion, electrical and thermal energy, the annual volume of secondary thermal energy resources was approximately 5 billion GJ (approximately 250 million tonnes of reference fuel). In other words, 35% of the energy resources consumed by the Soviet industry was expended on the heating of atmosphere. Use of secondary energy resources is economically sound since expenses on the saving of fuel by use of secondary energy resources are 2-4 times lower than the costs of its production and conveyance. However, even now secondary thermal energy resources, especially medium-temperature ones (50-400°C) are used by a mere 10% [3].

CONCLUSION

The existing levels and trends in the growth of energy consumption and the related air consumption and atmospheric pollution may have irreversible ecological consequences. To keep the Earth's atmosphere in an ecologically acceptable condition, air consumption and pollution must be reduced. The nuclear energy which allows to limit the use of organic fuel is one of today's and tomorrow's real alternatives. Ventilation is one of the basic air consumption sources (15%), which is connected, first of all, with the heating of air in cold seasons. Reuse (recirculation) of air which reduces heat expenditures by up to 25-30% and lowers emissions is a method of air consumption reduction in ventilation systems. Use of secondary medium-temperature air energy resources alone allows to reduce the reference fuel expenditure by up to 25%. It is advisable to control the working zone microclimate and the operation of ventilation facilities.

LITERATURE

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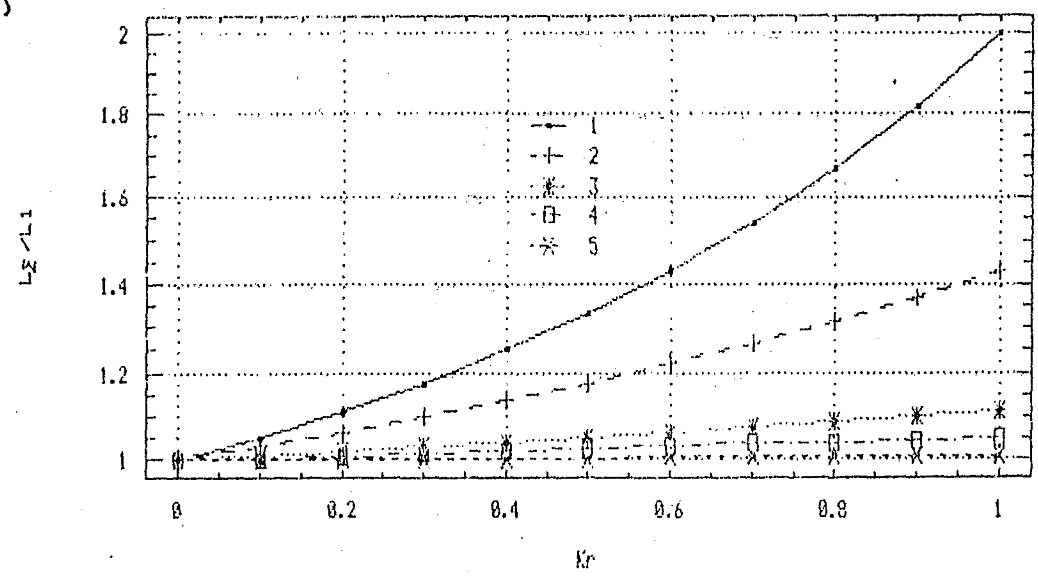
Change general air quantity on ventilation of premises in dependence from recirculation coefficient (Kr), cleaning degree (n) and supply air pollution (C1)

a)



a) C1=0; b) C1/Cg=0,3

1 - n = 0,5; 2 - n = 0,7; 3 - n= 0,9; 4 - n = 0,95; 5 - n = 0,99

b)

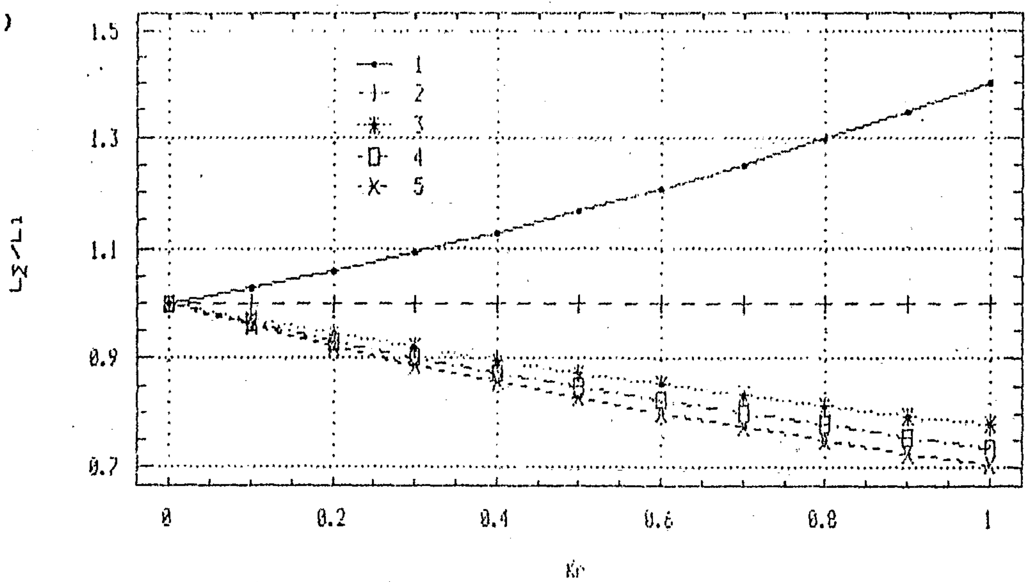


Fig. 1.