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CONSTRUCŢII. ARHITECTURĂ

RESEARCHES REGARDING THE EFFICIENCY OF WATER TO AIR HEAT EXCHANGER WITH HEAT PIPES FOR THE MECHANICAL VENTILATION SYSTEM

BY

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The present paper proposes the analysis of the efficiency of water to air heat exchanger with heat pipes for the mechanical ventilation system. The performed study is based on the necessity of the unconventional energy forms capitalization, increasing of the energy efficiency and the energy consumption decrease in concordance with the sustainable development concept.

1. Introduction

The energy consumption of the buildings totalizes approximately 40% of the final energy consumption in European Union, with a great recovery potential of the energy of 22% on short-term (until 2010). According to the Kyoto protocol, European Union proposed the reduction of gas emission to 8% until 2012, compared with the level in 1990. The buildings must play a very important role in fulfilling this aim.

The reduction of energy consumption in buildings has a special social-economical relevance that led to the intensive promotion of the energetical rehabilitation and modernization programs for the building equipments and envelope.

The capitalization of the unconventional energy forms and thermal waste led to the development and implementation of different types of heat recovery systems. There is a broad spectrum of heat recovery systems and heat exchangers, more and more improved and efficient, among which the heat pipes recovery systems possess a well-known place.

Although Romania is one of the countries in which heat pipes technology has been known and studied since 1970, the heat pipe recovery systems have been less used.

2. Description of the Model and of the Studied Cases

The use of insulated glazing units has as main disadvantage the lack of assurance of the necessary fresh air flux through natural exchange. This is the reason why directional mechanical ventilation systems are required in order to compensate the deficit. In these conditions, during the cold season, the external air that is introduced in rooms must be heated with the view to assure the comfort parameters. The thermal energy from a primary source or the residual energy can be used in this scope.

In order to improve the energy efficiency of the heating existent installations and to make up new equipment with characteristics that are adequate with respect to the requested functions, a heat recovery system with heat pipes has been designed and modelled.

The proposed heat recovery system (Fig. 1) is made up of two main zones: the heat assumption part, that takes the heat from a residual agent (return of a heating installation), and the heat transfer part, in which a previously established fresh air flow is heated by the heat pipes.

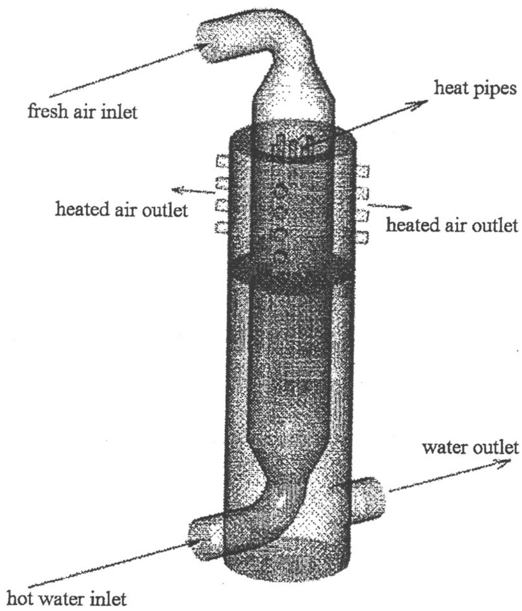

Fig. 1.– Heat pipes heat exchanger.

More functional hypothesis have been studied in order to underline the efficiency of this type of heat pipes recovery system.

The apparatus has been dimensioned in order to assure the fresh air ratio into an inhabited room with a volume of 68 m^3.

Regarding the fresh air inlet, four main cases have been analysed, according to the corresponding exterior temperatures of the Romanian climatic zones (–21°, –18°, –15°, –12°C) taken into calculus. In order to obtain a more complete prominence of the performances and transfer capacities of heat pipes, three intermediate zones with external air temperatures of –8, –5, and 0°C have been studied.

The flows and speed of the fresh air taken into calculus are in agreement with the I5-1998 Normative ("Normative Regarding the Design and Fulfilling of Acclimatization and Ventilation Installations"), while the flow and the speed of water were set according to the I12-2002 Normative ("Normative for the Design and Fulfilling of Central Heat Installations") for steel pipes with dimensions of 3/8"; 1/2"; 3/4".

In order to enlarge the heat exchange surface and to enhance the convective heat transfer, the air part was fitted with two types of turbulence promoters (wings on the surface of the heat pipes and longitudinal spirals between the heat pipes, into the air circulation zone from the condensation part of the heat pipes).

The heat pipes are made of copper, having a length of 1 m and 12 mm diameter.

3. Method and Obtained Results

In order to determine the functional parameters of the recovery system, the transmitted thermal flux and the outlet temperature of the heated air in different exploitation hypothesis, the three-dimensional thermodynamic simulation of the two working agents flow has been achieved by using the Fluent calculus programme.

The hot air agent and the speed at the input in the apparatus have been considered as constants (65°C and 0.35 m/s, respectively), according to the thermal agent flow from the return of the heating installation.

The air flow and input speed in the apparatus have been adopted with values of 34 m^3/h and 2 m/s, according to a ventilation rate of 0.5 exchanges per hour.

The obtained results of the simulation are presented in Table 1 and Figs. 2,...,4.

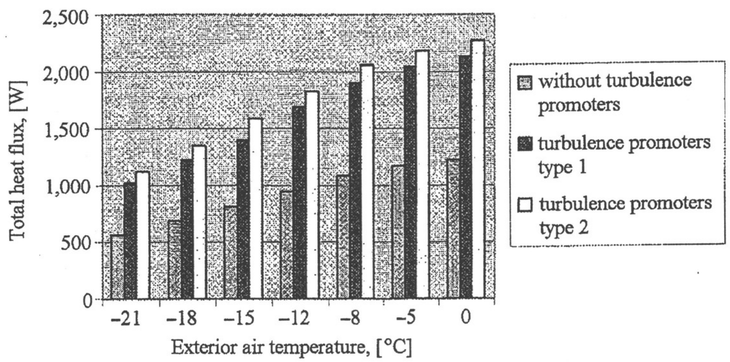

Fig. 2.– Correlation between the exterior temperature of the inlet air and the total heat flux.

Table 1

The Results of the Simulation: Case 1: without Turbulence Promoters; Case 2: Wings on the Surface of the Heat Pipes; Case 3: Spiral Turbulence Promoters

Case	Water inlet, t °C	Water inlet, v m/s	Air inlet, t °C	Air inlet, v m/s	Total heat flux W/m^2	Air outlet, t °C
1	65	0.35	–21	2	560	9.2
1	65	0.35	–18	2	690	10.8
1	65	0.35	–15	2	810	12.3
1	65	0.35	–12	2	920	15.1
1	65	0.35	–8	2	1,090	17.4
1	65	0.35	–5	2	1,170	19.8
1	65	0.35	0	2	1,230	20.6
2	65	0.35	–21	2	1,020	14.7
2	65	0.35	–18	2	1,220	16.2
2	65	0.35	–15	2	1,405	18.3
2	65	0.35	–12	2	1,684	20.1
2	65	0.35	–8	2	1,898	22.3
2	65	0.35	–5	2	2,048	24.6
2	65	0.35	0	2	2,140	26.1
3	65	0.35	–21	2	1,130	16.2
3	65	0.35	–18	2	1,270	17.8
3	65	0.35	–15	2	1,590	19.2
3	65	0.35	–12	2	1,825	21.4
3	65	0.35	–8	2	2,060	23.7
3	65	0.35	–5	2	2,185	25.9
3	65	0.35	0	2	2,280	27.4

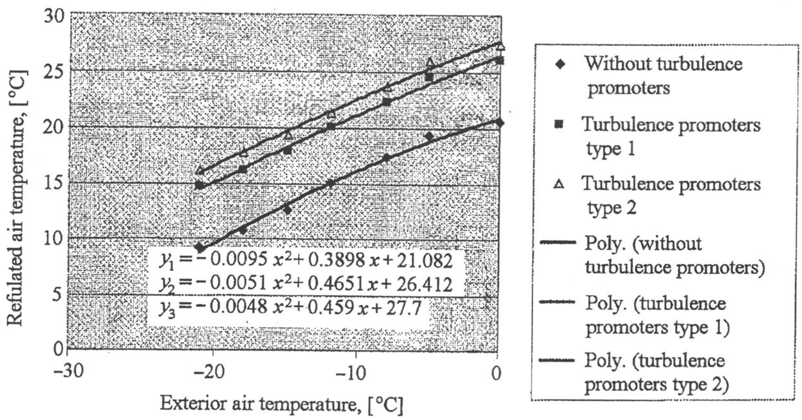

Fig. 3.– The equations of the temperature distribution.

Their analysis confirms the possibility of using the heat recovery system for the inlet air heating, for the considered hypothesis, to temperatures of –15°C and only when the turbulence promoters are used in order to intensify the heat exchange.

In the other cases, with temperatures lower than –15°C or without the use of turbulence promoters, the heat recovery system may be used only to preheat the air.

When the longitudinal wings are used on the condensation part of the heat pipes, the results show a maximum heat flux of 2,140 W and a refulation temperature of 26.1°C, according to the inlet fresh air temperature of 0°C. In the case of spiral turbulence promoters, the efficiency rises to 2,280 W and 27.4°C, respectively.

In order to exemplify, Fig. 4 underlines the temperature fields through a median longitudinal section of the heat recovery system for the case when spiral turbulence promoters are used.

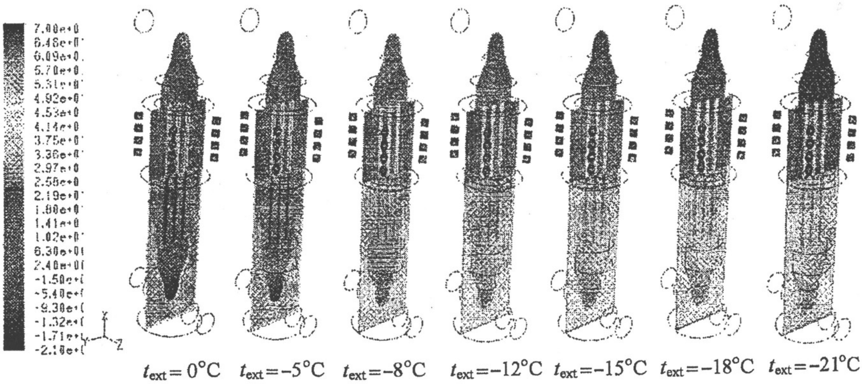

Fig. 4.– The temperature fields through a median longitudinal section of the heat recovery system for the case when spiral turbulence promoters are used.

4. Conclusions

1. The energy efficiency and comfort criteria requirements impose the prompt and permanent assurance of qualitative and quantitative parameters of the air in the rooms without natural ventilation.

2. The condition may be fulfilled by using the heat recovery system with heat pipes adequate for controlled mechanical ventilation installations.

3. The major advantages are obtained by using the heat pipes for heat recovery from the residual fluids in order to preheat clean fluids used in mechanical ventilation installations or for the preparation of the consumption hot water.

4. From the exploitation point of view, the heat exchangers with heat pipes don't have moving elements, so they determine low maintenance and use costs.

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CERCETĂRI PE MODEL PRIVIND EFICIENŢA RECUPERATOARELOR DE CALDURĂ APĂ–AER, CU TUBURI TERMICE, PENTRU INSTALAŢII DE VENTILARE MECANICĂ

(Rezumat)

Se efectuează analiza eficienţei unui recuperator de caldură apă–aer cu tuburi termice, pentru instalaţiile de ventilare mecanică. Studiul are la bază necesitatea valorificării formelor neconvenţionale de energie, creşterea eficienţei energetice şi reducerea consumului de energie în concordanţă cu cerinţa de dezvoltare durabilă.