NATURAL PHYSICAL CAVITIES AND DEVELOPMENT OF RENEWABLE AND SUSTAINABLE ENERGY TECHNOLOGIES

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Summary

Natural physical cavity. Quantification of annual temperature regime of natural physical cavity by in-situ experiment. Annual course of temperature of outdoor climate. Annual course of maximum temperature of natural physical cavity of optimal south–west orientation. Optimization of natural physical cavity geometrical quantification. Effective height of the cavity. Concept of new possibilities for energy utilization of air from natural physical cavities. Two-stage system for utilization of renewable energy sources. Heat pump with primary energy of thermally conditioned air from physical cavity.

Keywords: cavity, energy, temperature, air, experiment

1 Introduction to the problem of the paper, its subject and goals

Development of a new facade technology of double-skin facades based on the application of natural physical cavities leads us to a deeper understanding of their theory.

SUBJECT of the paper is therefore a natural physical cavity and that at least of a corridor type (width $0.6 < w\ (m) < 1.5$).

GOAL of the broadly conceived problem, part of which is this paper, is :

1. Quantification of its annual temperature regime in four distinctive seasons on the basis of in-situ experiment and that also in the relation to the model of outdoor climate in the form of test reference year for the locality of Bratislava,
2. Confronting the possibility of utilizing the energy regime of natural physical cavity for the function of heat pump with primary energy of thermally conditioned AIR from the physical cavity – *fig. 1*

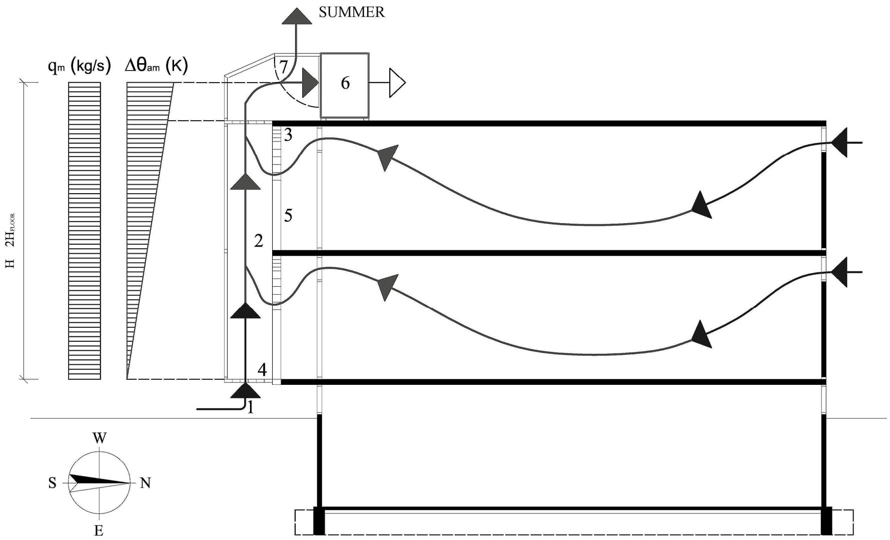

Fig. 1 *Scheme for utilization of the thermally conditioned air from the natural physical cavity – two level glazed space with effective height $H \approx 2\ H_{FLOOR}$ for heat pump 1 – inlet of air into the cavity, 2 – natural physical cavity, 3 – sun protection, 4 – ascendable shutter, 5 – railing, 6 – heat pump with primary energy of thermally conditioned AIR from the physical cavity, 7 – revolving flap (regime WINTER–SUMMER)*

The performance of a heat pump declines with the decrease of air temperature of outdoor climate θ_{ae} (ºC), or for the problem solved by us, it is the decrease of air temperature at the outlet from the physical cavity $\theta_{am,OUT}$ (ºC). There are two significant temperatures for the solved problem as we can see from the graphic dependence shown on *fig. 2* :

- air temperature ensuring 100% performance of a heat pump – optimal θ_{ae} = = opt. $\theta_{am,OUT}$ = +7ºC,
- air temperature ensuring 75–80% performance of a heat pump – critical θ_{ae} = = crit. $\theta_{am,OUT}$ = +1ºC.

2 Methodology of the paper

Methodology of the paper comes out from confronting the test reference year for the locality of Bratislava and from the long-term in-situ experiment with the aim to quantify the energy regime of the natural physical cavity of the same building.

Methodology for the second part of the paper utilizes the new knowledge about energy regime of natural physical cavities acquired from the in-situ experiment, based on the computational experiments by simulation program SSTT and the model of outdoor climate in the form of test reference year for the locality of Bratislava.

3 Presentation of selected results of in-situ experiment

According to the methodology of the paper, selected intervals of energy regimes of natural physical cavity in the four distinctive seasons, document for critical WINTER period, from which we can see that:

- for aver $\theta_{ae,\ M} \approx -2.3$ ºC, the variance of this temperature is $\Delta\theta_{ae} \approx 15$ K ($+7 > \theta_{ae}$ (ºC) > -8),

- in time intervals of day without direct solar radiation is the rise of temperature in the experimentally monitored natural physical cavity $\Delta\theta_{am} \approx 3$ to 4 K. This means that the temperature of air exiting the cavity is 3 to 4 K higher than the temperature of outdoor climate (transmission from the gradient of temperatures $\Delta\theta_a = \theta_{ai} - \theta_{ae,M} \approx 23.3$ K).

Summary analysis of the experimentally determined parameters of the energy regime of the mentioned natural physical cavity documents *fig.3*. We can see that in the problem solved by us, for the optimally oriented cavity of corridor type with the effective height of one floor is the utilization of thermally conditioned air from the physical cavity as a primary energy source of a heat pump not suitable. In the critical winter period, the air exiting the cavity is of negative temperatures $-5°C \leq \theta_{am,OUT} <$ crit. $\theta_{am} = +1°C$.

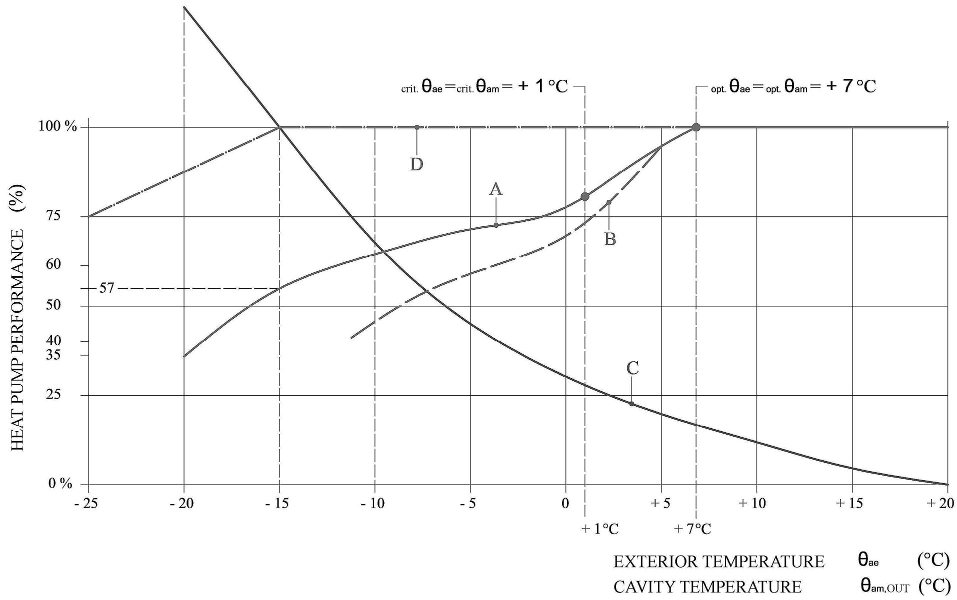

Fig. 2 *Dependence of decrease of the performance of heat pump with primary energy of AIR (AIR–WATER) from exterior – inlet temperature of air θ_{ae} (ºC), A – performance of inverter heat pump (with continuous output regulation), B – performance of heat pump ON/OFF (without inverter), C – energy demand for heating, D – attempts for new development technologies of heat pumps*

4 New knowledge about energy regime of physical cavity and the possibilities of its utilization

Solution to the mentioned problem forces us to look for ways of increasing the temperature of the air exiting the natural physical cavity in the winter period with such parameters which fulfill criteria: $\theta_{am,OUT} \geq +1°C =$ crit. θ_{am} or $\theta_{am,OUT} \geq +7°C =$ opt. θ_{am} – *fig. 2.* There are several ways that lead to an increase of the temperature of air exiting the physical cavity:

- decrease of air flow q_m (kg/s) through physical cavity – *fig.3*,
- increase of effective height of physical cavity – *fig.3*.
- increase of the effective height of a physical cavity in the combination with regulation of air flow within, documents *fig. 3.*
- modification of the physical cavity with openings for inlet (outlet) of air on each floor with an effective height max $H = 6\ H_{FLOOR}$ in accordance with the new knowledge about geometric classification of natural physical cavities.

Suggested modifications of the physical cavity lead to wide possibilities of variations in the creation of required parameters of energy regime, utilizable for a heat pump with primary energy of thermally conditioned AIR – *fig.3*.

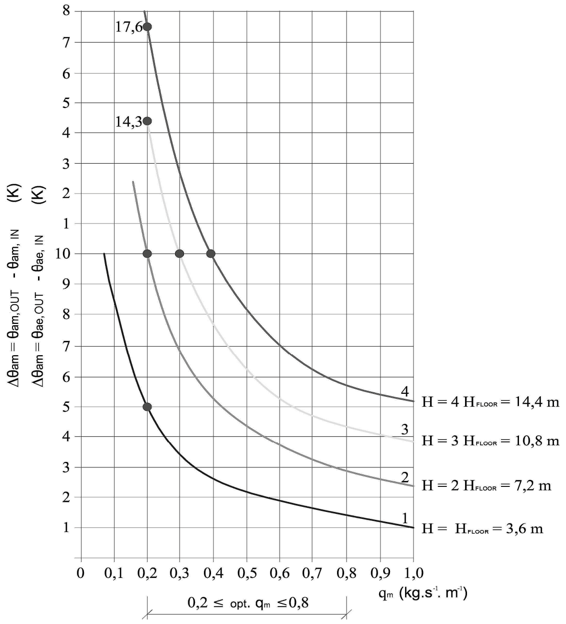

Fig. 3 *Graphic dependence $\Delta\theta_{am} = f(q_m)$ for a natural physical cavity of corridor type of the double-skin transparent façade with closed circuit in winter period. South orientation (S). Average approximate values for the climatic conditions of the test reference year in winter period in the locality of Bratislava*

5 Conclusions

Variations of effective height of physical cavity H (m), modified by the regulation of air flow q_m (kg/s.m) in acceptable interval 0.2 < q_m (kg/s.m) < 0.8, expressing the effective efficiency of physical cavity, provide wide possibilities in the design process of cavities of the required physical parameters crit. $\theta_{am,OUT} \geq +1$ºC. In the characteristic winter period with the lowest temperature of outdoor climate min. $\theta_{ae} \approx -8$ºC, this required critical parameter is reached at rise of temperatures in the cavity $\Delta\theta_{am} = \theta_{am,OUT} - \theta_{am,IN} \approx 10$ K – *fig. 3*.

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References

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