Earth-to-Air Heat Exchanger: hygro-thermal performance

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1 Introduction

The earth-to-air heat exchanger (EAHX) is a pipe buried in the ground through which air is sucked into a building. In this paper, moisture performance of EAHX was studied by means of careful long-term monitoring of real-size exchanger (passive family house in Rychnov near Jablonec nad Nisou) and numerical simulation (own model for simultaneous heat and moisture transfer in EAHX). The model has already been compared with analytical solution to a theoretical case of externally insulated exchanger with harmonic oscillation at the input [Hollmuller, 2003]. Moreover, two short-term hygro-thermal simulation tests have been performed so far in order to compare simulation with monitored data (chosen summer data with heavy condensation, measured in 2006 and 2007). The model showed perfect agreement with the analytical solution and satisfactory agreement with experimental data.

2 Tendency to condensation

Due to damping of soil mass, soil temperature is substantially lower than ambient air temperature in summer. Soil temperature primarily depends on locality, upper plane surface heat balance and soil thermal properties. Simultaneously, absolute humidity of air is the highest during summer. The tendency to condensation was evaluated with measured data, see Figure 1.

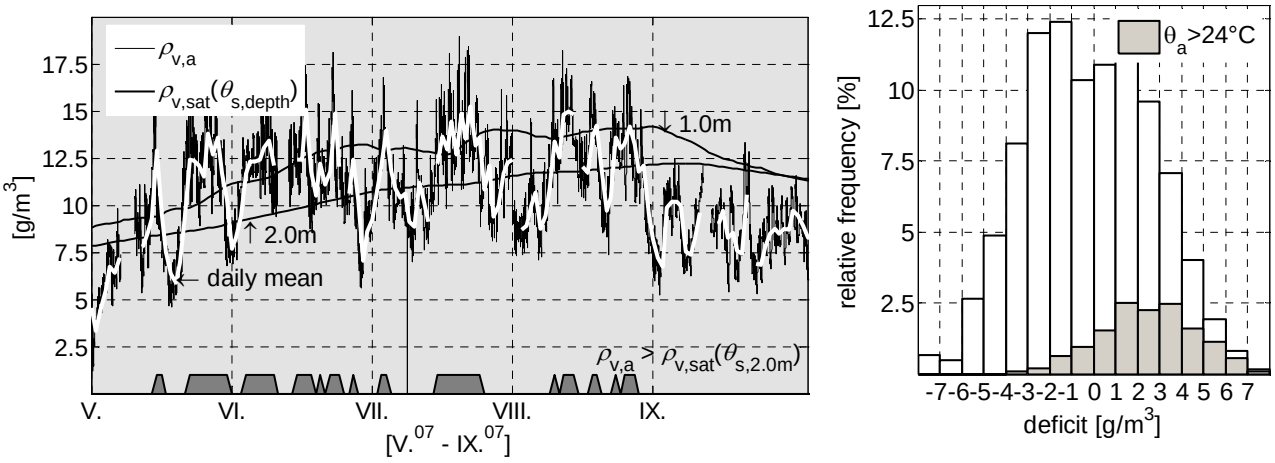

Figure 1: Left – water vapour concentration of ambient air $\rho_{v,a}$ and saturated water vapour concentration $\rho_{v,sat}$ as a function of soil temperature $\theta_{s,depth}$, measured data in 2007. Right – relative frequency of difference between water vapour concentration of ambient air and saturated water vapour concentration for soil temperature in depth of 2 m (measured data May – September 2007), deficit = $\rho_{v,a} - \rho_{v,sat}(\theta_{s,2.0m})$.

Condition $\rho_{v,a} > \rho_{v,sat}$ occurred roughly 1300 h (~54 days) for depth of 2 m, and 613 h (~25 days) for depth of 1 m. As seen in Figure 1, right, evaporation (negative deficit) cannot frequently occur during hot days of summer term (condition $\theta_a > 24$ °C). It means that during hot spells (air is sucked through EAHX) moisture tends to accumulate in the exchanger.

3 Key parameters

Moisture performance of EAHX is inherently linked with thermal performance, i.e. air temperature drop (saturation limit) is related to instantaneous humidity of inlet air. Daily oscillation of ambient air temperature and humidity, thermal properties of soil near pipe, instantaneous soil temperature (link to annual soil temperature oscillation and EAHX previous operation), and configuration of the pipe (diameter, length, air flow rate) play role. Generally, all measures for reduction of condensed amount lead to decrease of thermal performance (i.e. to increase of outlet air temperature).

The parametric analysis identified input parameters to which moisture performance (condensed amount) of EAHX is particularly sensitive. The most sensitive parameters, which dominantly influence moisture performance, are instantaneous soil temperature and temperature and humidity of inlet air. Thus, risk of water vapour condensation is higher during spring when soil is cooled down after winter term. Low inlet air temperature leads to lower outlet air temperature and thus higher risk of condensation. High air humidity is also very important factor, especially simultaneously with low inlet air temperature.

4 Conclusion

Condensation inside EAHX can occur rather frequently in climate of middle Europe and probably can not be absolutely eliminated by EAHX design. Therefore, the inspection of real size EAHXs with a camera and some microbial investigations would be very valuable. Mould growth inside pipes should be still questionable, although the several existing studies, e. g. [Fluckiger, 1999], have not confirmed any hygienic problems.

Acknowledgement: This outcome has been achieved with the financial support of the Ministry of Education, Youth and Sports of the Czech Republic, project No. 1M0579, within activities of the CIDEAS research centre.

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