EXPERIMENTAL AIR GROUND HEAT EXCHANGER – OPERATING EXPERIENCE AND ITS USE IN A TEACHING OF AN ENVIRONMENTAL ENGINEERING

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Summary

The paper presents some outcomes of monitoring of experimental air ground heat exchanger (AGHE), which was built in FME BUT in 2011. This equipment is primarily attended for education, and tutorial problems based on data acquired are gradually created. Here, two of them which are focused on an evaluation of utilizability and heat gains of the AGHE in winter season are presented. Under winter conditions, average heat output approx. 0.5 kW and heat gains about 3–4 kWh per month are indicated.

Keywords: ground heat exchanger, ventilation, warm-air heating, cooling, energy savings

1 Introduction

Air ground heat exchangers (AGHE) as an optional equipment of HVAC systems appear to be able bringing energy savings with relatively easy way. Their principle is quite simple – a relatively stable temperature of soil under the ground level is exploited for pre-heating of ventilating air in winter, and for its cooling in summer. Consequently, energy demands and operating costs of warm-air heating or ventilating could be decreased.

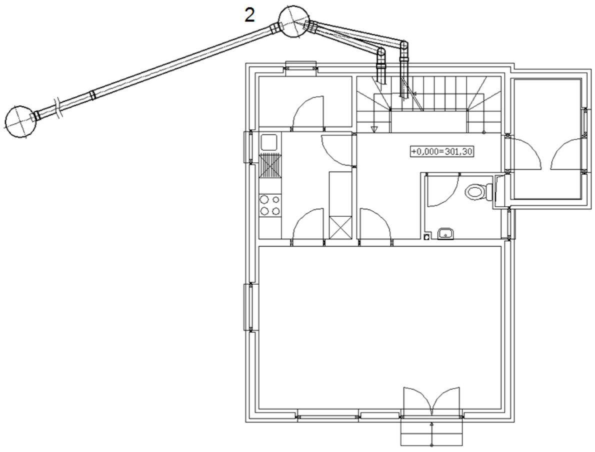
These features are very attractive, and so a number of AGHE installations in the CR quickly graduates. They are exploited especially in warm-air heated low-energy or passive dwellings. For example, only in the region of south Moravia, more than 15 new AGHEs were introduced into operation in last ten years (from 2002).

However, this equipment brings not only benefits. On the other hand, a potential hazard of microbiological pollution (as a mold creation, microbe propagation etc.) could arise here. Moreover, real economic asset is in many cases questionable, when the energy and consequent economic savings would be compared to investment costs [1].

Therefore, a project of experimental AGHE was proposed and realized with support of G1/3206/2011 grant provided by Universities Development Fund of MEYS CR in 2011. Its main aim is to familiarize the students of environmental engineering with this relatively novel HVAC device, to give them a practical experience with its operation, benefits as well as potential hazards, and to create reference data for evaluation of its real assets.

2 Device description

The described AGHE is composed as a complement of an experimental low-energy house of FME BUT. With respect to the free exploitable area, a bent ground plan had to be chosen (**Fig. 1**). Both brands – the forward and the backward – are dug one over the second in depths (measured to the center line) of 1.4 and 2.0 m, respectively, under the ground level. The AGHE is proposed in circulating variant; however, switchable T-valve enables to operate it in a direct regime, with a suction of outdoor air through the building façade, as well. Furthermore, two vertical chambers are embedded, which join constituent pipelines. This configuration enables additional operating regimes to realize. The device is equipped with a stepwise controlled fan in the piping outlet and a monitoring system. The detailed description of whole plant can be found in [2].



Parameters of the GHE

Type	Circulation
Pipe diameter	DN 200
Length of pipeline	2×15 m + connection
Wall thickness	4.9 mm
Material	KG PVC (SN 4)
Thermal conductivity	0.15 W/(m·K)
Average depth of deposit	1.3 m 2.0 m

Fig. 1 *Outline of an experimental AGHE*

3 Experimental data and their evaluation

As mentioned above, the device is primarily attended for educational purposes. The acquired data are therefore transformed into sets which create basis for various tutorial examples.

First such example refers to possible winter utilizability of the AGHE and it is based on data shown in **Fig. 2**. Here, a comparison of outdoor air temperatures during late winter and early spring (February 15 to April 23) to them in the soil (in an AGHE level) is presented. As can be seen, although the soil temperatures gradually decrease during winter, they are still over freezing point, and the AGHE can be therefore used as an anti-frost protection of subsequent HVAC equipment (e.g., heat recovery exchanger, HRE). This utilization of AGHE is one of most exploited (with respect to hazard of fatal damage of HRE with frozen condensed air humidity). As it is apparent from **Fig. 2**, this danger could be relevant up to end of April.

Tab. 1 *Time of exploitation of the AGHE for different switching temperatures (15.2.–21.4.2012)*

Temperature [°C]	Operating Hours [h]	Operation Period [%]
0	298	18.5 %
2	449	27.9 %
4	626	38.9 %

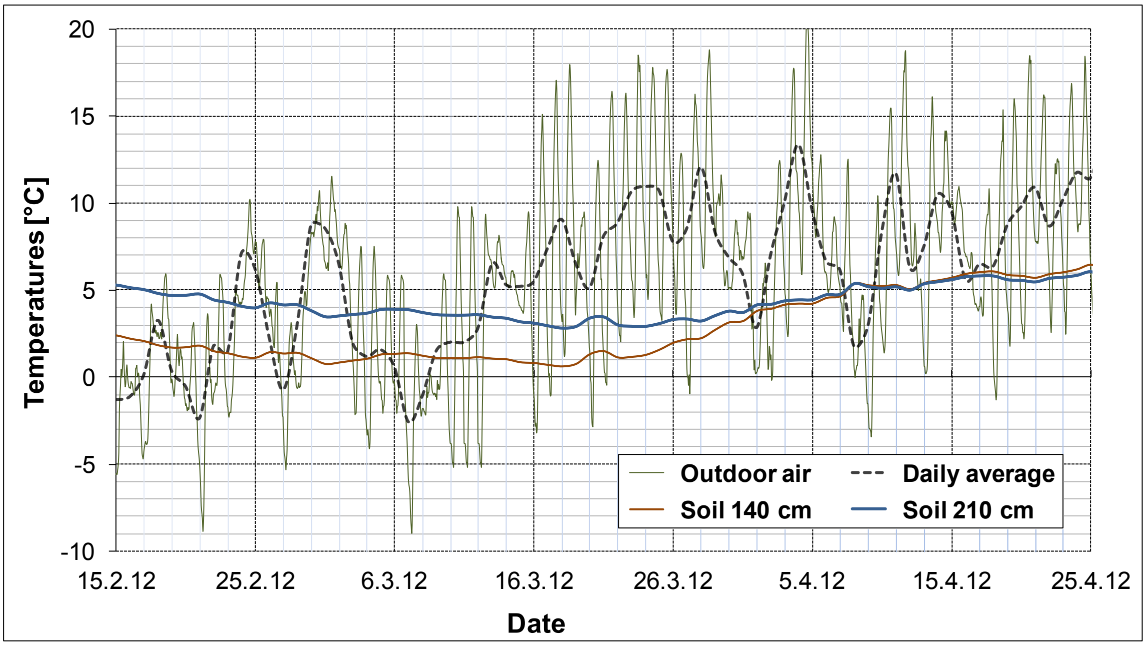


Fig. 2 *Comparison of outdoor and soil temperatures in late winter*

Evaluation of utilizability of the AGHE for this purpose is presented in **Tab. 1**. The total time of utilization depends significantly on a setting of a switching threshold between direct suction of outdoor air into the HRE and its pre-heating in the AGHE. Usual range recommended is 0 to 4 ºC (although some authors admit temperatures under the zero point, see e.g. [3]). However, the safer scope is chosen here.

Further example is attended on an evaluation of energy savings under continual operation regime (which is recently preferred by users – unlike the intermittent regime supposed and simulated in [1]). The relevant air temperatures and consequent heat output of the AGHE are presented in **Fig. 3**. The airflow rate (evaluated from an average airflow velocity) was during operation constant, equal to 185 m^3/h. The possible energy savings resulting from the preheating of ventilating air (although they are, in fact, lower when the AGHE is combined with a heat recovery – see e.g. [4]) are evaluated as

$$Q = \sum_i \dot{Q}_i \cdot \tau_i = \sum \dot{m}_i \cdot c_p \cdot (T^i_{outlet} - T^i_{outdoor}) \cdot \tau_i = \sum \dot{V}_i \cdot \rho_i \cdot c_p \cdot (T^i_{outlet} - T^i_{outdoor}) \cdot \tau_i \quad (1)$$

It is apparent, that under certain conditions (e.g. a thaw) the current air temperature can be higher than that in the soil, and the AGHE has then negative heat output. Therefore, some kind of control is very suitable to apply.

4 Conclusions

The presented data indicate that the AGHE is able to warm up passed outdoor air above the freezing point during whole winter season. Therefore, its exploitation as an anti-frost protection is quite correct. Its heat output depends on outdoor conditions; for typical winter conditions (outdoor air temperatures between 0 to –5 ºC) it is about 0.5 kW. However, under specific conditions it could be negative, and so some operating control is proper to apply. Total heat gains for continual working regime make approx. 1.1 kWh for ten days period evaluated, i.e. about 3–4 kWh per month (in winter season).

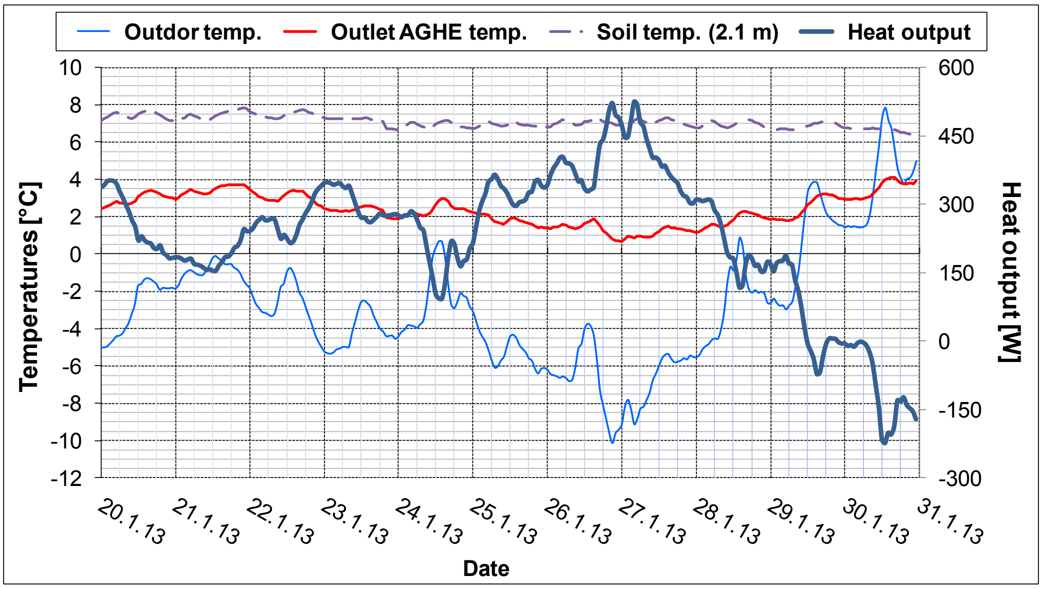


Fig. 3 *Relevant temperatures and heat output of the AGHE under typical winter conditions*

The authors believe that real operating data will help to familiarize the students of Environmental Engineering with possibilities and limitations of AGHEs for appropriate practical application. Their current work is focused on another problem of AGHEs – possible microbiological hazards and their detection in-situ.

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