Field Test of Pit Heat Stores – Construction and First Results

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1. Motivation

At the Institute of Thermodynamics and Thermal Engineering field tests on different concepts and designs of pit heat stores are carried out in the frame of the project "Further Development of the Pit Heat Storage Technology", funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. The main emphasis is the development of an efficient and cost-effective hot-water pit heat store for seasonal heat storage, particularly in combination with solar assisted district heating systems. Suitable materials like insulation, liners, geotextiles and vapour barriers are tested in two outdoor laboratories.

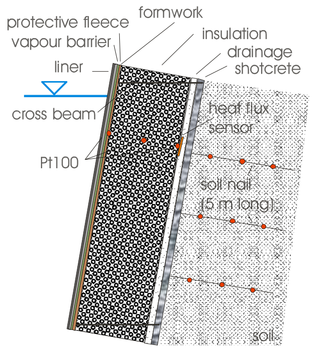
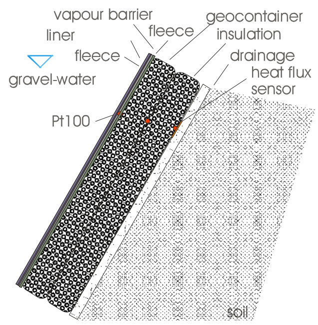
Figure 1: Field tests - the two outdoor laboratory-pit heat stores: left hot- water-pit heat store with floating cover, right gravel-water pit heat store, (cover not yet completed).

2. Material and Processing

Two pits (inverted pyramid trunks, each about 200 m³) have been built. The pits have 80° slope secured with soil nails and shotcrete as well as natural slopes with 60°. Due to the soil nailing steeper slopes and consequently better A/V-ratios can be realised. Smaller A/V-ratios lead to reduced heat losses and thus to a more economic construction.

The wall construction of pit heat stores is mounted directly on the slope. In order to prevent the permeation of surface water into the insulation, the slope is covered with a drainage layer. The actual wall construction is mounted on top of that. Table 1 compares two different wall designs.

Table 1: Comparison of two types of wall construction

scheme of the wall constructions		
Slope	80° - soil nailing with shotcrete	60° - natural slope
Insulation	60 cm bulk in lost formwork	36 cm bulk in geocontainer (2 layers)
Insulation material	foamglass granules 4-8 mm	foamglass granules 2-4 mm
Heat Conductivity	0.06 W/mK (measured at 20 °C)	0.06 W/mK (at 20 °C)
Vapour Barrier	preconfected Aluminum-composite liner (PP-PA-Al-PA)	reinforced PE-Al foil, overlapping, fixed with tape
Liner	TPE-rolls, hot-wedge-welded	EPDM, 2 preconfected liners hot-air-welded

On the insulation protective fleece, vapour barrier and liner are installed. Each single layer is fixed in a ditch. The liner is welded with a hot-air or a hot-wedge welding machine. The double joint can be tested for leakage by compressed air.

Figure 2 shows the mounting of the insulation (foam glass granules) by blowing it in different types of formwork.

Figure 2: Air injection of the insulation (foam glass granules) from the silo-truck, and from left to right: geocontainer, membrane formwork and prefabricated wooden formwork.

3. Minimisation of the heat losses

The thermal conductivity of the insulation can be calculated using the measured heat fluxes as well as the storage and insulation temperatures. In figure 3 trends of the insulation mean temperatures and the thermal conductivity are plotted. The comparison of the calculated values with the thermal conductivity measured with a heating plate device allows the prediction of the insulation's moisture content and thus conclusions regarding the functionality of the liner:

1) The thermal conductivity of the wall insulation is in the range of the values gained by the experiments with the heating plate device (~0.06 W/(m K)).

2) The thermal conductivity of the bottom insulation (foamglas gravel) is significantly higher than the values measured with the heating plate device (~0.08 W/(m K)). By heating the store the insulation is desiccating, but the thermal conductivity is with 0.12 W/(m K) 50 % above the laboratory values (compare figure 3).

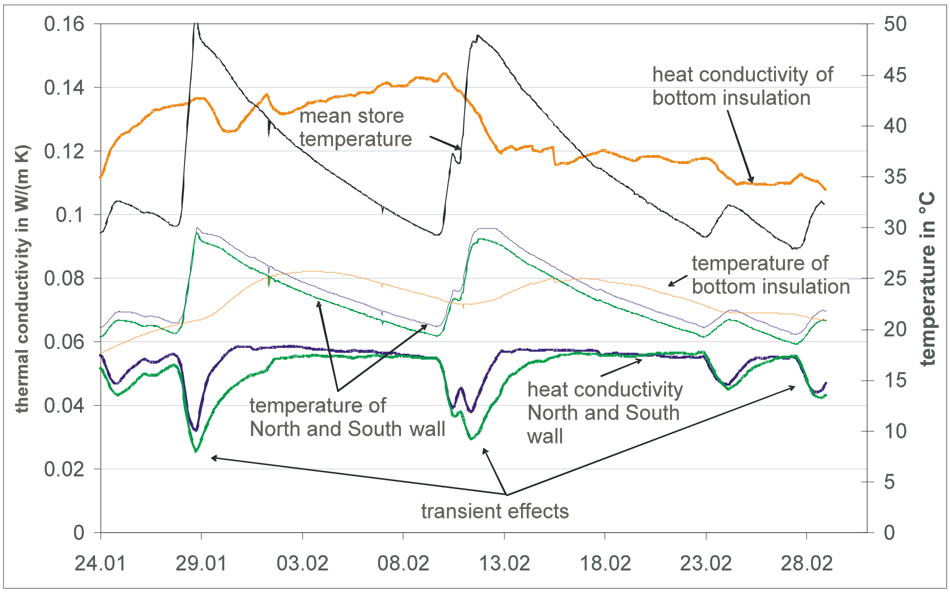


Figure 3: Trend of the thermal conductivity and the mean temperatures of the North and South wall as well as of the bottom insulation of laboratory 2.

4. Floating Cover

In contrast to gravel/water pit heat stores hot water pit heat stores require a sophisticated cover. One possible solution is a floating cover. The tested floating cover is installed in the empty basin. The insulation is packed between the bottom and the top liner of the cover and forms the floating body. By filling the pit heat store with water, the cover is floating (buoying). The insulation and the roof foil for the edges are installed after the floating. The cover is accessible. Figure 5 shows the floating cover after the filling of the laboratory 1. The edge insulation and the rain cover have been installed later.

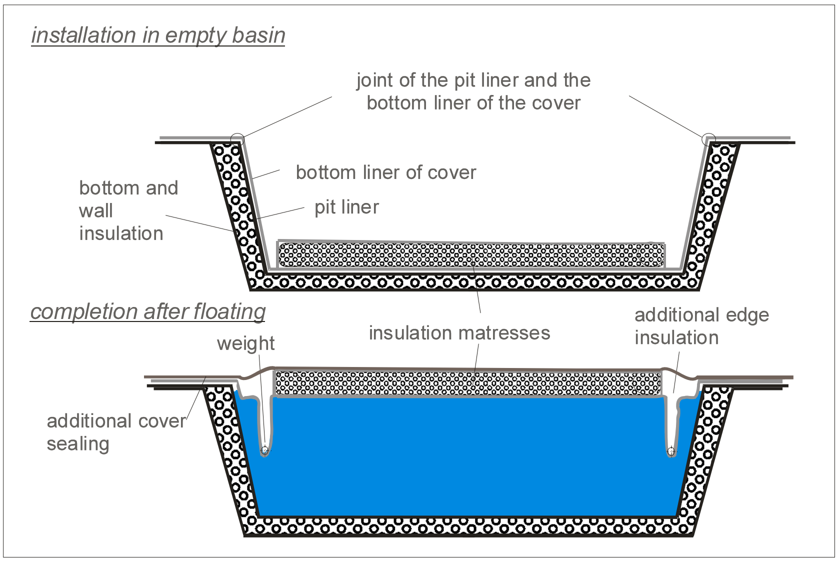


Figure 4: Scheme of the floating cover

Figure 5: Photo of the floating cover, edges area not yet insulated

The floating cover has following advantages:

1) Installation on the floor of the empty basin (no difficult on-water installation).

2) Changes of the level can be tolerated (loose cover).

3) Emptying of the store is possible without complete destruction of the cover.

5. Conclusions

1) A pit heat store is an efficient and cost effective seasonal heat store.

2) By soil nailing pit heat stores with steep slopes and consequently with optimized A/V-ratios can be built.

3) A floating cover is suitable for large hot-water pit heat stores.

4) The insulation must be kept dry: the construction must be water and vapour proof towards the inside and water proof but open for water vapour diffusion towards the soil.

Further field tests and the construction of a 500 m³ research pit heat store for long-term monitoring are scheduled.

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