SELF-ASSESSMENT OF SCIENTIFIC CONTRIBUTIONS

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of publications presented for the B4 group of indicators

(habilitation thesis)

Scientific contributions

1. Three paraffin MPFS E53, E46 and ECP are characterized thermo-physically (phase transition temperatures, latent heat, heat capacity - at constant pressure, density and thermal conductivity). The Raman structural study determined the aliphatic nature of the E53 paraffin sample, while the E46 and ECP samples also contained unsaturated components due to their Raman characteristics in the range of 1500 to 1700 cm^{-1} [B4.1] (over 48 observed citations in 7 years);
2. The first of its kind large-scale and systematic comparison between the field and laboratory tests for determining the thermal characteristics of ground heat exchangers and between the different approaches to the laboratory tests has been realized. Valuable guidelines are given for their features and areas of application [B4.5] (over 35 citations noted in 3 years);
3. Mathematical modeling and 3-D numerical simulation studies were performed in order to predict the thermal behavior (in the process of phase transformations) of heat accumulators with paraffins (as MPFS) and the factors influencing the heat transfer process before the physical experiment. [B4.2, B4.3] (6 citations noted);
4. A new hybrid approach and method for measuring the efficiency of vertical ground heat exchangers (BHE) and the surrounding underground thermal properties has been proposed and tested, which combines the traditional thermal response test (TRT) with the method of well temperature relaxation (TR thermal response).), based on two-dimensional radial conductive heat transfer. The new method allows: (1) assessment of how convective heat losses in groundwater layers affect the assessment of groundwater thermal properties; (2) study of the uneven heat transfer through the BHE to stratified underground layers; and, (3) calculating the depth dependence of the thermal properties of the unsaturated subsoil. [B4.6] (5 citations noted);
5. Developed and tested (in the evirionment of LabVIEW™) is a new, original set of virtual tools. It allows to provide online or offline calculations of the uncertainty of the measurements, as well a statistical hypotheses testing. A series of calibration and operation tests were performed to verify the operation of the virtual instruments and some hybrid heating installation components (including a new PV/T panel design). During the tests, online trends of the uncertainties for the quantities of interest were observed, which allows timely termination of the test and correct selection of the measuring interval. The tests show that there is poor thermal contact between the pipe and the back of the panel plate. This led to a change in its design. It has also been found that at higher temperatures, the heat transfer in the PV/T panel

deteriorates and its energy output is better. So parallel connection should be preferable for heat exchangers with PV / T panel. [B4.7] (5 citations noed in 1 year)

6. A 3D mathematical model of the process of conducting a test to determine the thermal characteristics (TRT) has been created. In order to analyze the correctness of the simulations, the results of the numerical modeling were compared with the experimental data and showed a good match. Based on these results, it is possible to estimate the temperature field around the well. In addition, the digital model easily takes into account different heat transfer rates by setting the water temperature at the inlet of the BHE to simulate the process, for example charging or discharging the system with BHES for a desired duration. In addition, the number of boreholes can be increased to the desired number of BHE depending on the heat needs of the users, thus recreating large-scale heat energy in the borehole. It has been found that the additional use of 3D numerical simulations of TRT provides a more reliable tool compared to analytical methods [B4.10] (3 citations noted).

Scientifically applied contributions

1. A review of the available options for modeling shallow geothermal energy storages (SGES) has been performed. The main analytical and numerical models and methods related to the thermal behavior of SGES are presented. The most important additional factors influencing such modeling are discussed: (1) boundary conditions; (2) spatial dimensions (scale); (3) the determination of the parameters of SGES; (4) short-term versus long-term analysis; (5) the impact of groundwater. Subsequently, issues related to the modeling of thermomechanical interactions, which may be crucial for energy geostructures, are addressed. A detailed overview of the main software tools related to thermal and thermo-hydromechanical analysis of SGES [B4.9] is given. (3 citations noted)
2. A small hybrid installation containing a daily and seasonal accumulators and supporting five different operating modes, with an emphasis on charging a borehole heat exchanger (BHE), a heating mode with an ground source heat pump (GSHP) and subsequent natural relaxation was studied. A methodology for determining the energy efficiency of the various regimes has been developed. High quality data on the efficiency of the various modes of operation of the system in terms of soil and meteorological conditions typical of the Plovdiv region were obtained and analyzed. [B4.8] (11 citations noted in 1 year);
3. A number of experimental sewen-day tests were performed to determine the thermal characteristics of the soil in the region of Plovdiv. The data from the measurements were processed and values were obtained to characterize the thermal resistance of BHE and the thermal conductivity of the soil [B4.6, B4.8 B4.10].

Applied contributions

1. An overview of the different types of heat storage systems (concentrated on underground heat accumulators and MPFS accumulators), their technical

characteristics, advantages and disadvantages and a comparative analysis [B4.4.] (10 citations noted).

2. The construction of a latent heat accumulator was developed and studied using the paraffins E53, E46 and EC [B4.1] studied by the authors, as MPFS [B4.2, B4.3].
3. Developed, built and put into operation is a small hybrid installation containing daily and seasonal batteries and supporting five different modes of operation with an emphasis on charging a drilling heat exchanger (BHE), heating mode with ground-connected heat pump and subsequent natural relaxation [B4.8].

Submitted by:

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