ТЕХНИЧЕСКИ УНИВЕРСИТЕТ–СОФИЯ
ФИЛИАЛ ПЛОВДИВ

СЛУЖЕБНА БЕЛЕЖКА

№51/06.06.14

Редакционния борд на годишника на ТУ – София, Филиал Пловдив Journal of Fundamental Sciences and Applications, издава настоящата бележка в уверение на това че статията:

„ИЗМЕРВАТЕЛНА СИСТЕМА НА ХИБРИДНА ИНСТАЛАЦИЯ СЪС ЗЕМНО БАЗИРАНА ТЕРМОПОМПА И СЛЪНЧЕВИ КОЛЕКТОРИ"

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е приета за отпечатване в том 20 за 2014 г.

Главен Редактор:

/проф. дфн дтн М. Ненчев/

Директор Филиал:

/проф. д-р инж. М. Петров/

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Plovdiv branch, Bulgaria
"Fundamental Sciences and Applications" Vol. 19, 2013
International Conference Engineering, Technologies and System
TECHSYS 2013
BULGARIA

ИЗМЕРВАТЕЛНА СИСТЕМА НА ХИБРИДНА ИНСТАЛАЦИЯ СЪС ЗЕМНО БАЗИРАНА ТЕРМОПОМПА И СЛЪНЧЕВИ КОЛЕКТОРИ

ЕМИЛ ТОШКОВ, АЛЕКСАНДЪР ГЕОРГИЕВ, РУМЕН ПОПОВ

Резюме: *В статията е представена измервателната система на инсталация със земно базирана термопомпа и слънчеви колектори за кондициониране на жилищни сгради. Описани са сензорите за измерване на параметрите на системата и приборите за събиране и обработка на данни. Направен е анализ кои параметри трябва да се измерват при различните работни режими на инсталацията – отопление, охлаждане и зареждане на земята с използване на различни източници на енергия.*

Ключови думи: *земно базирана термопомпа, слънчеви колектори, хибридна система, измервателна система*

MEASURING SYSTEM OF A HYBRID INSTALLATION WITH GROUND SOURCE HEAT PUMP AND SOLAR COLLECTORS

EMIL TOSHKOV, ALEKSANDAR GEORGIEV, RUMEN POPOV

Abstract: *The measuring system of an installation with ground source heat pump and solar collectors for air conditioning of residential buildings is presented in this article. The sensors for parameter measuring of the system and the devices for data collecting and treatment are described. An analysis is performed which parameters are to be measured at different installation working modes – heating, cooling and charging of the ground by means of various sources of energy.*

Key words: *ground source heat pump, solar collectors, hybrid system, measuring system*

1. Introduction

The Ground Source Heat Pump (GSHP) systems are promising for long-lived heating and cooling because they are using the ground like heat source or sink with nearly constant yearly temperature. The combination of solar collectors with GSHP is the way to make such systems more effective – higher COP and better working conditions [1, 2]. It is possible also to use the solar energy from collectors directly for space heating and to store the thermal energy into the ground when it is abundant [3]. That helps to keep the ground temperature constant and to avoid the so called thermal depletion of soil when the system operates a long time [4].

The aim of the present paper is to represent the measuring system of such experimental installation – the sensors and devices which collect data during experiments and the parameters in different modes – heating, cooling and thermal charging.

2. Description of the GSHP system

An experimental system with ground source heat pump and solar collectors was constructed at the Technical University – Sofia, branch Plovdiv (the main scheme is presented in Fig. 1) [5].

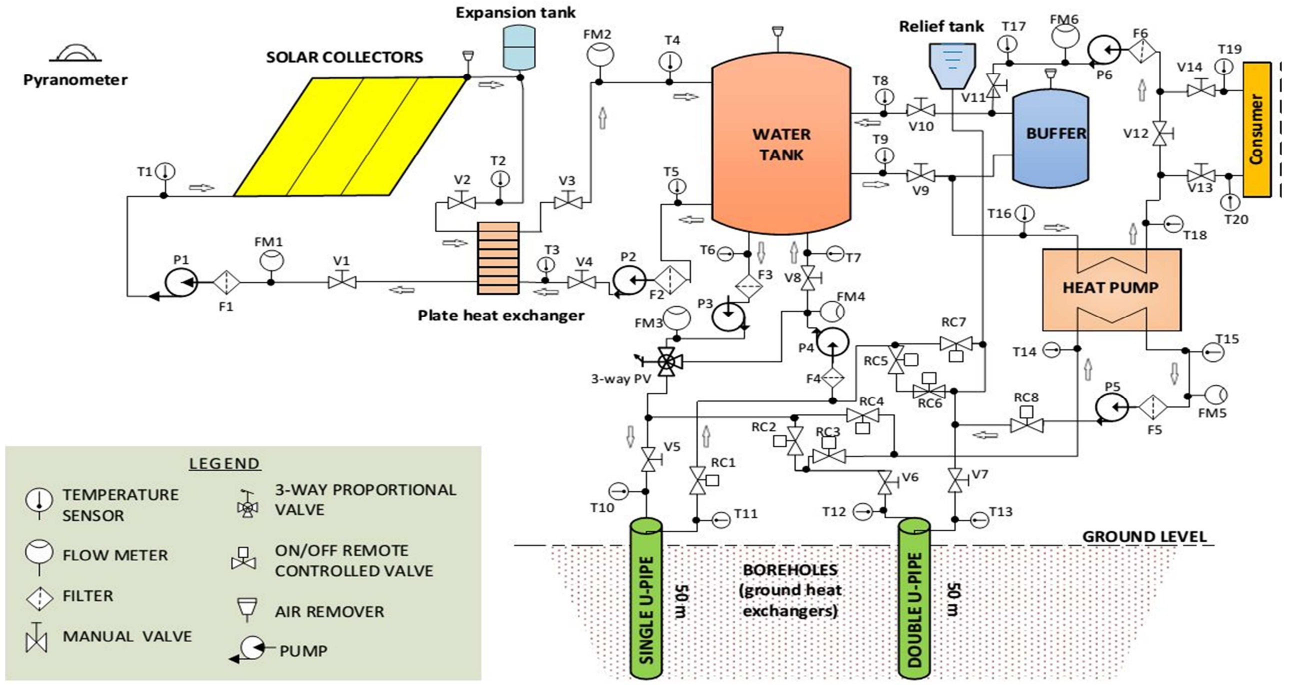

Fig.1 *Main scheme of the hybrid installation [6]*

It consists of the following main parts:

- Two borehole heat exchangers (BHE) - 50m of depth and 165 mm in diameter each; they are of a single and double piping type;
- Three flat plate solar collectors in parallel with 2,15 m^2 area eash ("Sunsystem" Ltd, Bulgaria); they are equipped with a pump station P1 and expansion tank;
- Brazed plate heat exchanger of the type GEA; it transfers the heat from the solar loop to the water storage tank;
- Water storage stainless steel tank with a volume of 300 l - it is thermally insulated;
- Heat pump water – water (production of "Maxa", Italy); it is controlled by a microprocessor based device "Eliwell", Italy;
- Buffer vessel with thermal insulation – 150 l;
- Convector of the air-water type – it is used like a heat consumer;
- Water pumps: two DAB JET 82M centrifugal pumps with Active Driver 1.1 M P4 and P5; they are used to deliver flow to two boreholes;
- Water pumps: two wet rotor circulating pumps DAB VA 35/130 P2 and P3: they are used to deliver the flow to the storage tank and boreholes;
- Water pump of the type DAB Evoplus P6 with electronic control for the consumer loop;
- Plastic relief tank with a volume of 10 l;
- Eight remote controlled 2-way valves Hertz TS 90 with thermal actuating drive 220V (RC1 – 8) are used to control the water flows in different modes during the system operation;
- 3-way mixing valves of the type VMBT4-Italy with proportional actuating drive MVT57; they are used to inject thermal energy from the water tank to the boreholes;
- Manually opened valves V1-V14;
- Piping – 32mm polypropylene tubes Aquatherm with thermal insulation "Aeroflex".

3. Measuring system of the installation

A/ Sensors: they are needed to measure the operating parameters – temperatures, water flow rates, electric power, integral solar radiation, and to provide data to the data logger, which is necessary to calculate the energy transfer between the main elements of the hybrid system and effectiveness in the different working modes.

Temperature: the sensors are of the type 3-wire platinum resistors Pt100, class A in special copper closed tubes; they are fitted on every input and output of the constituent system parts T1-T20 (Fig.2). The sensors are mounted into polypropylene T-diverter on a water flow – that assures precise measuring of the inlet and outlet temperatures.

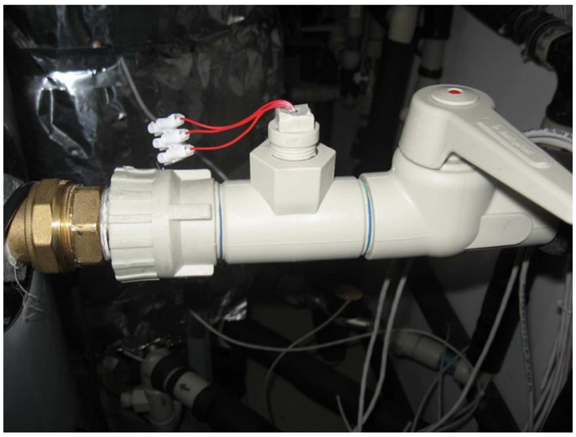

Fig.2 *Temperature sensor Pt 100 in housing*

Volumetric flow rate: six flow meters BEL90 FM1-FM6 are mounted on every circulating loop – the maximal flow rate is till 5 m^3/h and the digital pulse output offers sensitivity of 10 l/pulse (Fig. 3).

Fig. 3 *Digital flow meter BEL 90*

Solar radiation: a pyranometer of the type Kipp & Zonen CMP 6 (Holland production) is mounted on the roof with the aim to measure the global solar radiation, which falls in the area of the thermal collectors (Fig.4). Its technical characteristics are as follows *[6]*:

- Spectral diapason – 285-2800 nm;
- Sensitivity – 12 μV/W/m^2;
- Response time – 18 s;
- Maximal radiation – 2000 W/m^2;
- Visible field – 180^0;
- Temperature diapason: -40 till +80°C.

Fig.4 *Pyranometer CMP 6 [6]*

Electric power: Wattmeter EL-EPM02FHQ is used to measure the electric consumption of the heat pump and the water pumps with accuracy of 0,5W and till 3,6 kW as a maximum load *[7]* (Fig. 5).

Fig.5 *Wattmeter EL-EPM02FHQ [7]*

B/ Measuring devices: they are used for the most important parameters – temperature and flow rate. The hybrid system is equipped with devices for parameter measuring and logging the obtained data on PC. It is produced by the company "Comeco"- Bulgaria *[8]*.

Programmable Indicator TC800: it has the following characteristics:

- 8 inputs, 8 outputs and 16 alarms;
- 2 displays;
- Programmable ranges and alarms;
- Self-testing and system-failure alarm;
- RS485 serial interface available;
- 24 VAC power supply.

TC800 performs measuring and logging of temperature by means of Pt100 with digital compensation for RTD sensor line resistance and accuracy of 0,4 % from span. A rich set of parameters allows programming every aspect of controller operation and an RS485 serial interface allows network operation or connection to operator station. It is possible also to use some channels for voltage inputs – to measure the value of the solar radiation from the pyranometer (Fig.6).

Fig.6 *Indicator TC800 [8]*

Programmable Counter CT34: it has the following characteristics *[8]*:

- Pulse counting and batch counting;
- One or two 6-digit LED displays;
- Programmable divider and multiplier;
- 2 programmable relay outputs;
- RS485 serial interface available;
- 6 user-selectable operating modes;
- 24 VAC power supply.

With the help of this counter the volumetric flow rate of circulating water in different loops is measured and the data are logged on a PC (Fig.7).

All the measuring devices are coupled to a PC with an universal USB-to-Serial converter to log the data in the desired intervals of time 1-15 min.

An universal data acquisition program "Polymonitor" is used for logging data to a PC with RS485 interface.

Fig 7. *Programmable Counter CT34 [8]*

4. Working modes of the installation and the need to measure some parameters

The hybrid installation for heating and cooling of residential buildings can operate in 6 different modes depending on the seasonal conditions and needed load. That assures versatility and flexibility of the installation during the four seasons of the year with the aim of effective and low cost operation. The operating modes are as follows *[5, 9]:*

1. Solar energy diurnal storage – thermal energy (when present) is delivered to the water storage tank from the solar collectors.
2. Charging of the borehole storage – thermal energy (when present) is delivered during the summer to the boreholes from the solar collectors and the condenser of the heat pump.
3. Direct solar heating – a thermal energy from water tank is sent directly to the consumer.
4. Ground-source heat pump heating – the heat pump is working and the heat delivered to the evaporator of the heat pump come either from the single or double borehole heat exchanger.
5. Heating with solar assisted heat pump – the heat pump is operating and the heat sources are the solar collectors, respectively the water storage tank.
6. Ground source heat pump cooling – the boreholes are connected in this mode to the condenser of the heat pump.

There is the possibility to carry out two modes simultaneously - for example ground source heat pump cooling with the double BHE when charging the single one with solar energy. The main parameters that have to be measured during different operating modes are presented in Table 1.

Table 1. *Measuring parameters during different operating modes*

N=	Working mode	Pumps in operation	Temperatures to be controlled	Flow rate to be controlled	Solar radiation measuring
1	Solar energy diurnal storage	P1. P2	T1, T2, T3, T4	FM1, FM2	Yes
2	Charging of the borehole storage	P1, P2,P3, P4	T1, T2, T3, T4,T6, T7,T10,T11,T12,T13	FM1, FM2, FM3, FM4	Yes
3	Direct solar heating	P1, P2, P6	T1, T2, T3, T4, T8, T9, T19, T20	FM1, FM2, FM6	Yes
4	Ground-source heat pump heating	P5, P6	T8,T9,T10,T11,T12,T13,T14, T15,T16, T18, T19, T20	FM5, FM6	No
5	Heating with solar assisted heat pump	P1, P2, P4, P5	T1, T2, T3, T4, T6, T7, T8, T9, T14, T15,T16, T18, T19, T20	FM1, FM2, FM4, FM5	Yes
6	Ground source heat pump cooling	P5, P6	T8,T9,T10,T11,T12,T13,T14, T15,T16,T17, T18, T19, T20	FM5, FM6	No

The hybrid geothermal system can operate with either single or double loop borehole heat exchangers during heating and cooling modes. Also there is a choice which borehole to be used for charging of the thermal energy in the soil – the single or double one.

5. Conclusions

The main conclusions are the following:

A measuring system is equipped to a hybrid installation with ground source heat pump and solar collectors. It allows measuring the main operating parameters – temperatures, volumetric flow rates, electric power consumption and integral solar radiation. All the data can be logged on a PC in desired time intervals.

The installation can operate at different regimes with the aim to achieve optimal conditions for space heating and cooling during the measurement of the working parameters. Also the hybrid system has the possibility to store thermal energy to the boreholes and to the water tank and to use it in different operating modes.

Acknowledgments

This work has been supported financially by the:

- Research project 132ПД0022-24/ 28.03.2013 of the Technical University of Sofia;

- Research project N° BY-TH 212/06 “Design and construction of a mobile testing unit for performing in-situ determination (Thermal Response Test, TRT) of geothermal properties of the ground (thermal conductivity and diffusivity) and implementation of some TRTs at different locations in Bulgaria involving monitoring and data analysis”. Bulgarian National Science Fund. 2006 – 2011.

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