Model compilation of ground source heat pump heating system for optimization in term of energy consumption.

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Abstract:

This paper describes part of a research project, which aims to optimize heat pump systems with borehole heat exchanger in terms of energy consumption. System consists of 100m borehole, heat pump, storage tank and control. After describing the above in more detail, the paper will present model compilation of ground source heat pump heating system at CTU in Prague used for heating of a part of laboratory. Model is compiled in simulation program TRNSYS. Currently, data that will be used for calibration of the model, are obtained and analyzed.

Abstrakt:

Článek popisuje část výzkumného úkolu, který se zabývá navrhováním různých konfigurací systémů s tepelným čerpadlem a svislými zemními vrty. Cílem výzkumu je optimalizace systémů z hlediska spotřeby energie na vytápění a chlazení budov. Po detailnějším popisu zařízení instalovaném v areálu Českého vysokého učení technického v Praze sloužícího pro vytápění laboratoří Ústavu techniky prostředí, je v tomto článku popsán postup sestavení modelu systému. Model je sestaven v simulačním programu TRNSYS. V současné době probíhá příprava měření pro shromažďování a analyzování dat. Získaná data budou využita pro kalibraci modelu.

1. Introduction:

The aim of the research project is to optimize heat pumps systems with borehole heat exchangers in term of energy consumption. The objective is to determine the most suitable configuration with a relevant control strategy. In regards to a great number of different system orderings, for the first research only basic configurations are selected (see Fig. 1). Heat pumps are devices with a dynamic behavior during heating/cooling season hence a mathematical simulation describing whole year is used. Models are compiled in simulation environment for the transient simulation of systems TRNSYS (Transient System Simulation Program) [L1] and finally they will be compared in term of energy consumption. A comparison of vertical ground heat exchanger design software gives Shonder [L2, L3]. Model of one ordering will be calibrated on a real system of a ground source heat pump system used for heating of a part of laboratory at CTU in Prague.

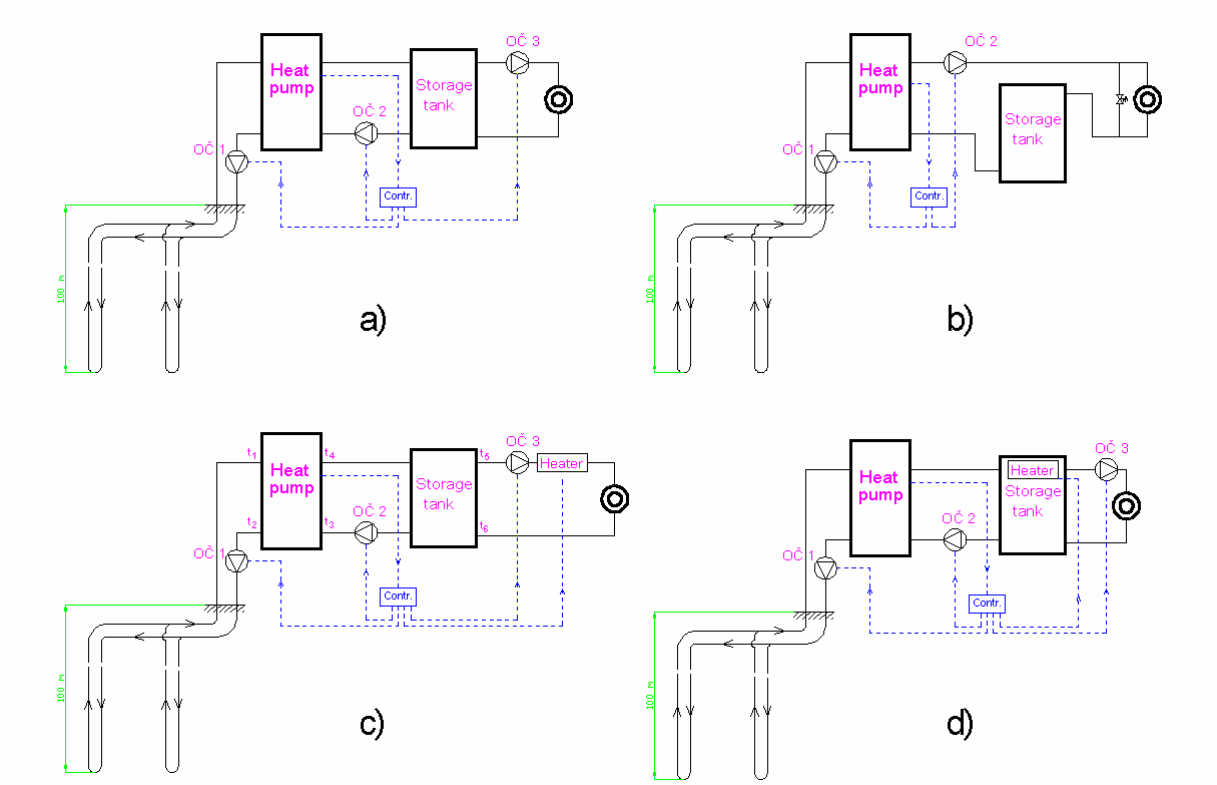

Fig.1: Configurations of ground source heat pump systems: a) monovalent system with storage tank separating system, b) monovalent system with storage tank on return pipe, c) monoenergetic system with auxiliary heater on supply pipe d)monoenergetic system with auxiliary heater in storage tank

2. System description:

System configuration consists of 100m borehole with double U-tube configuration, water-to-water heat pump 10 kW, storage tank 540 l, circulating pumps and involved control (see Fig. 2). Control of heat pump is operated depending on output water temperature from heating system.

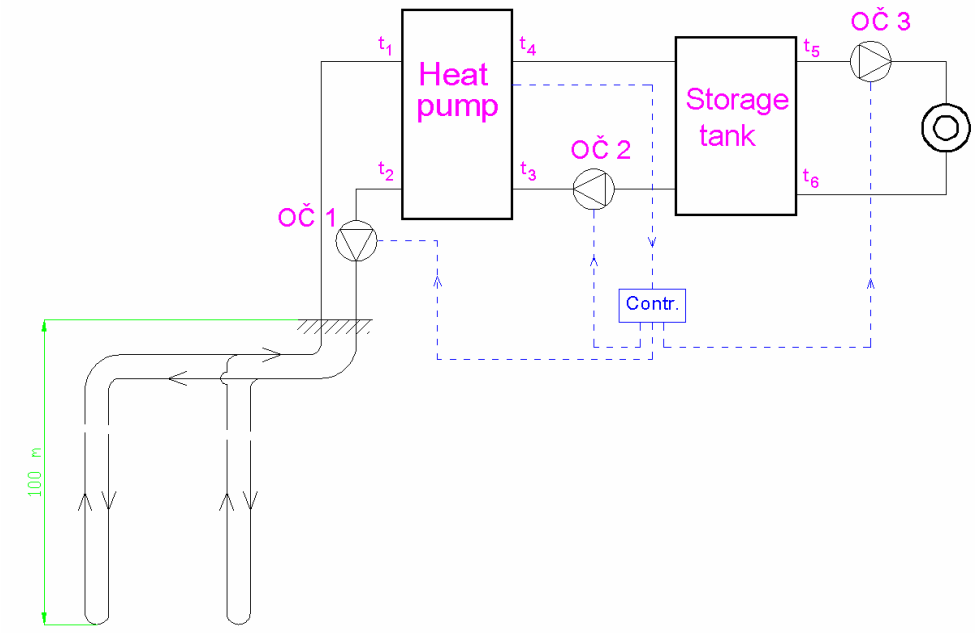

Fig.2: System is used for calibration purposes.

3. Model compilation:

Model is compiled in simulation environment for the transient simulation of systems TRNSYS see Fig 3.1. System is composed of these main components: type 109 (Data Reader and Radiation Processor), type 668 (Water to Water Heat Pump), type 557 (Vertical U-Tube Ground Heat Exchanger) [L4, L5, L6, and L7], type 56 (Multi-Zone Building) and type 60 (Storage Tank; Fixed Inlets, Non-Uniform Losses). Macro representing the heat pump control uses 3 components, type 62 (TRNSYS / Excel Coupling), type 24 (Quantity Integrator) and type 661 (Delayed Output Device) see Fig. 3.2. Flowchart describing control of system is programmed in Excel file and with the used component type 62 is coupled to TRNSYS.

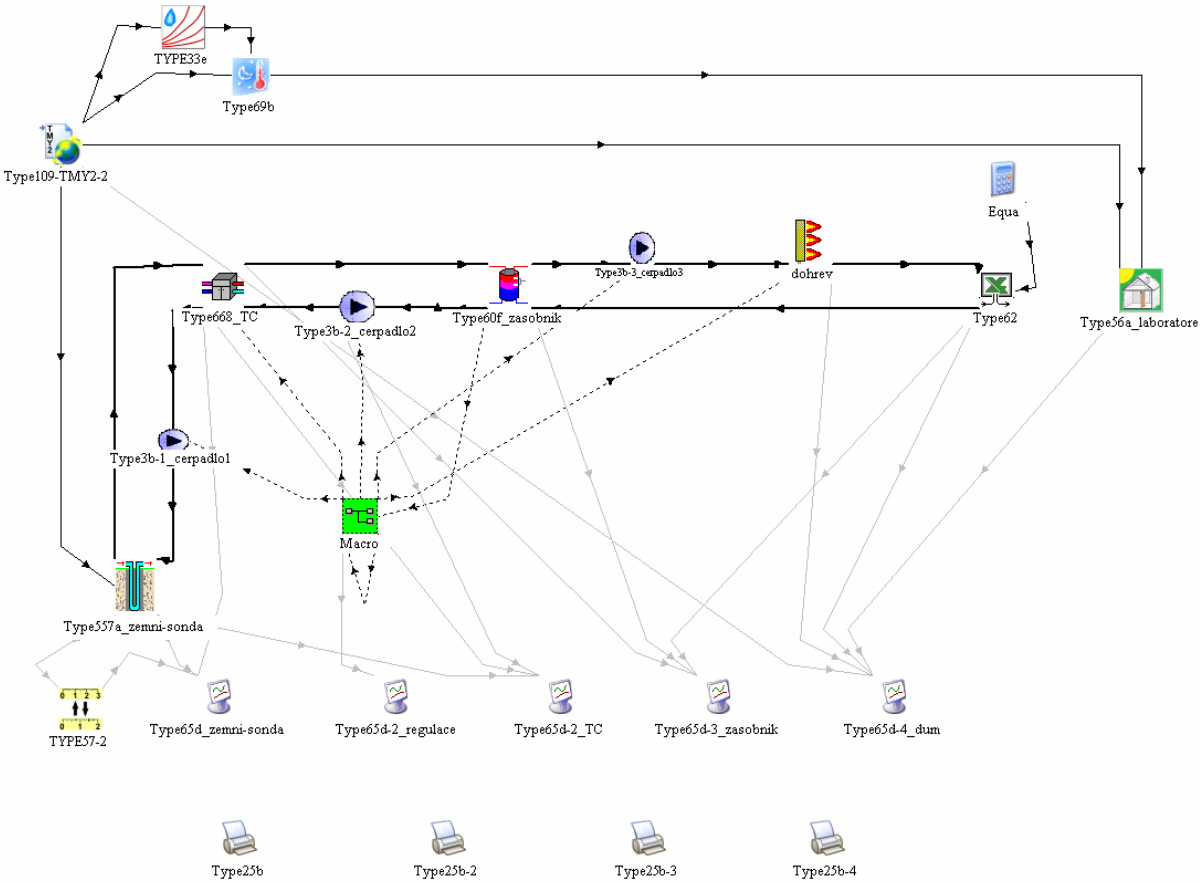

Fig.3.1: Model of ground source heat pump system compiled in simulation program TRNSYS.

Fig.3.2: Macro representing control of ground source heat pump system

4. Model calibration:

Calibration of the system is being carried out at equipment at CTU in Prague (see Fig. 4). For calibration purposes the system will be provided with temperature sensors and flow meters for annual measuring of the required data. Temperature sensors are located in pipes at primary and secondary circuit of heat pump, in pipes at secondary circuit of storage tank, in 3 vertical positions in storage tank for measuring temperature stratification, ambient temperature and temperature in technical room. Model calibration will be realized with ambient temperature and measured values of heating load (inlet and outlet temperatures and flow rate into radiators). For simulation purposes these components will be replaced with components type 109 (Data Reader and Radiation Processor) and type 56 (Multi-Zone Building).

Fig.4: Ground source heat pump system on CTU in Prague, Faculty of Mechanical Engineering

5. Conclusion:

Currently the model of ground source heat pump system with borehole heat exchanger is compiled. Behavior of the model can describe behavior of a real system in operating conditions in area of control (see Fig. 5.1 and 5.2). Calibration of individual components is expected in next steps at the real system at CTU in Prague. At present only temperatures (see Fig. 5.4) and flow rates at heat pump are obtained. Heat capacity data are presented on Fig. 5.3. In the last step a compilation of other systems variants and simulated behavior of systems in different conditions is planned. Results will be obtained for 3 different calculation outdoor regional temperature (-12, -15, -18), 3 different meteorological data sets (a typical meteorological year, an extremely warm and extremely cold year), 2 different building types (light, heavy).

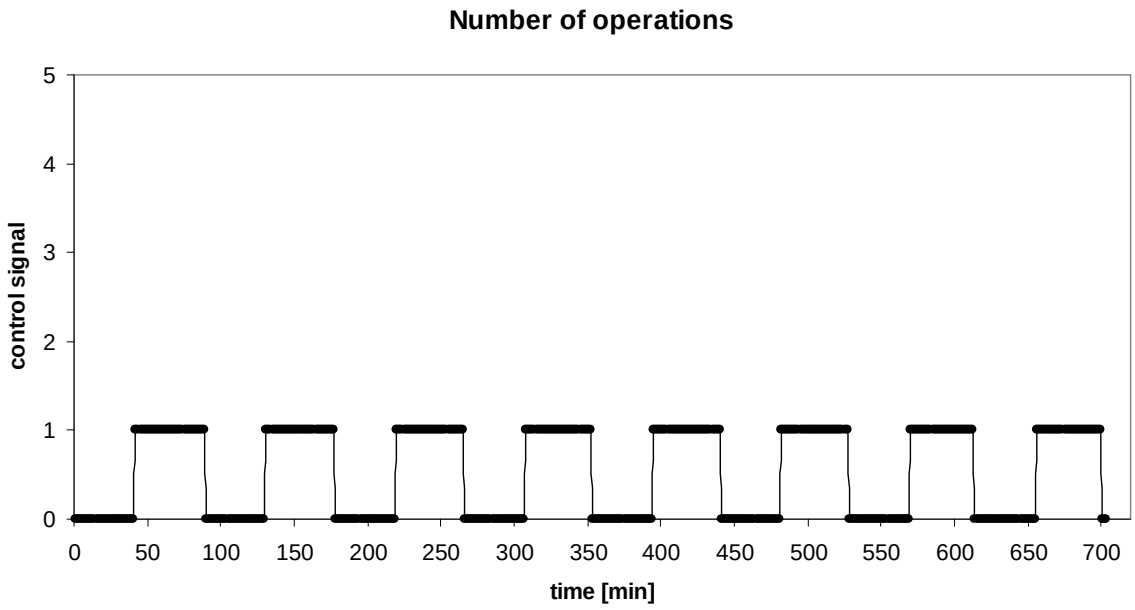

Fig.5.1: Measured data – Number of operations, start 18.1.2007 (10:40)

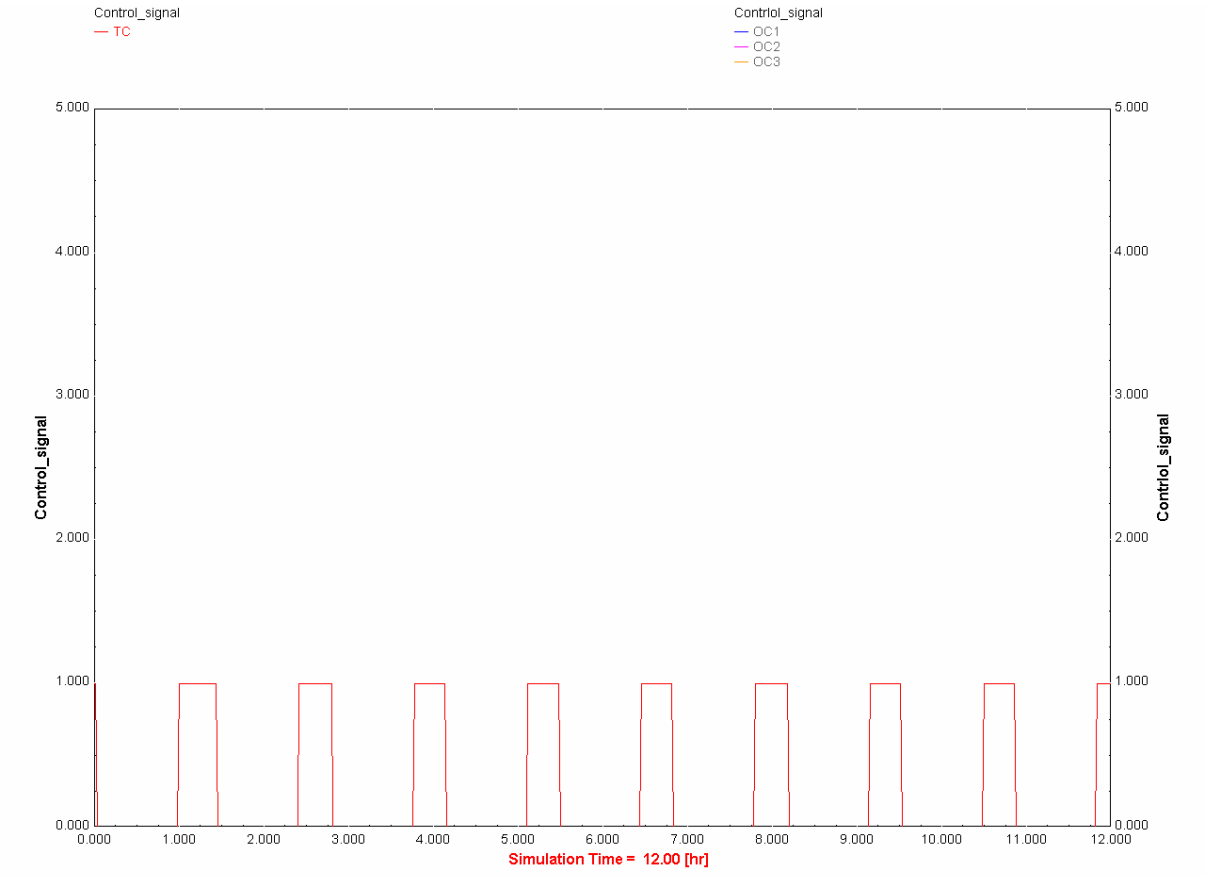

Fig.5.2: Simulated data– Number of operations, start 18.1.2007 (10:40)

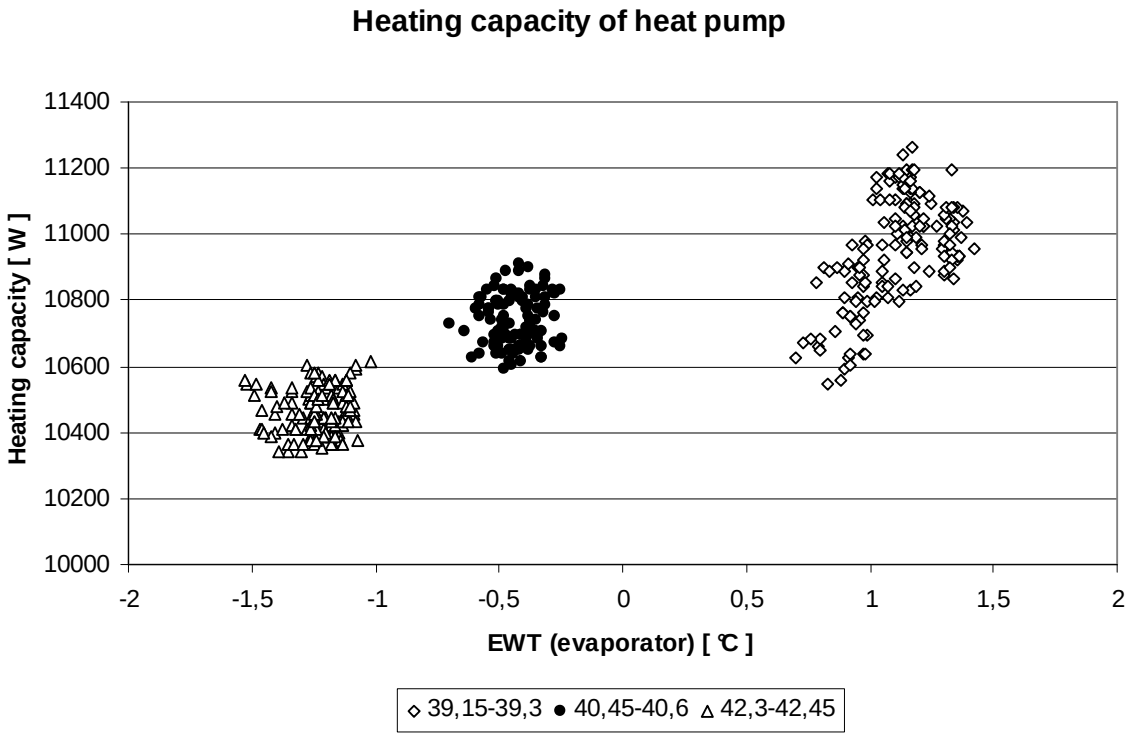

Fig.5.3: Measured data – Heating capacity of heat pump

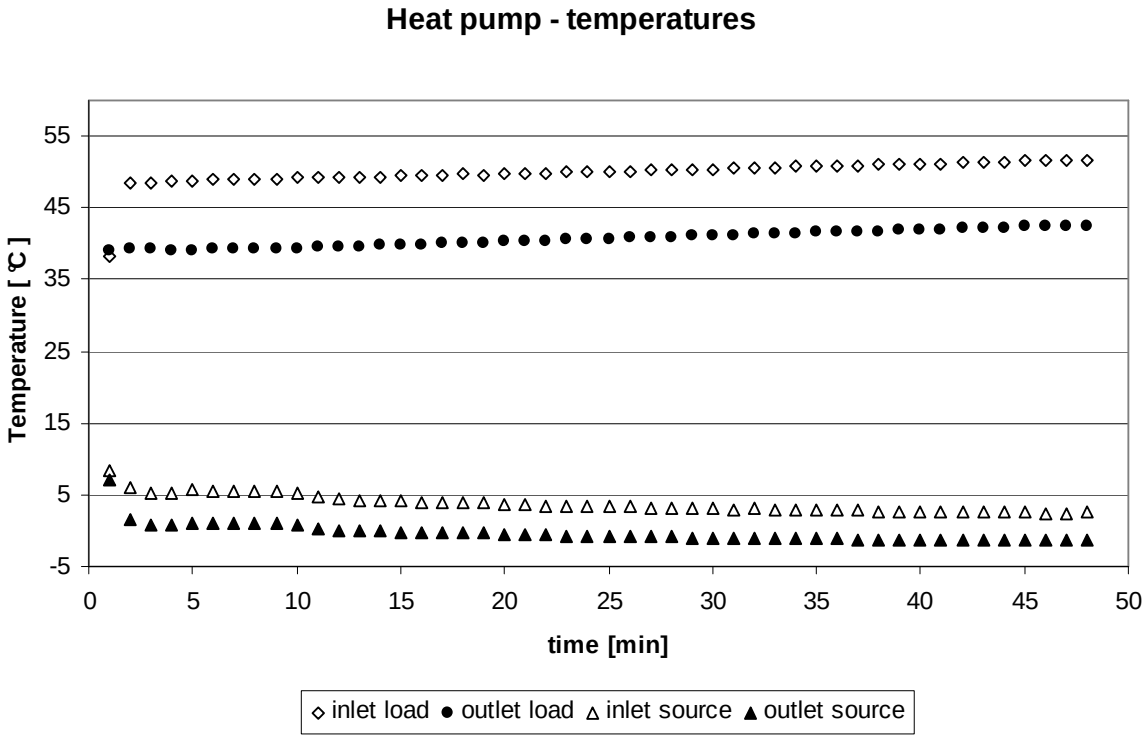

Fig.5.4: Measured data – Temperatures at primary and secondary site of heat pump

Nomenclature:

OČ	circulating pump
EWT	entering water temperature
t	temperature

Acknowledgment:

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