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Application of Shallow Geothermal Energy Systems for Space Heating and Cooling in the City of Mostaganem

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ABSTRACT

Shallow geothermal energy (SGE) is a renewable energy source that has become a sustainable alternative for heating and cooling buildings and infrastructure in many parts of the world. The research presented aims to quantify and valorize this shallow energy using a geothermal heat exchanger via a heat pump. A 3D numerical study based on the finite element method has been developed using "COMSOL Multiphysics" software, taking the climatology of the region concerned, the thermal properties of the site's soil and the interactions between the atmosphere-soil-heat exchanger into consideration. This work is divided into three parts: firstly, Richards' equation is used to calculate hydraulic variation as a function of time to determine Volumetric water content. After obtaining the volumetric water content the thermal conductivity of the soil and the volumetric heat capacity of the soil are deduced in order to determine the soil temperature profile, in the end heat transfer in the pipe is added to quantify the energy transferred to buildings for heating and cooling in the city of MOSTAGANEM.

Keywords: renewable energy, shallow heat exchanger, heat transfer, convection.

1. Introduction

Ground-source heat pumps are a highly promising and efficient renewable energy technology for space heating and cooling. This is because the ground is able to provide a lower temperature, relative to the building space, once cooling is restored and a higher temperature when heating is required[1]. Horizontal heat exchangers (HGHE) are closed loop heat exchangers that are designed to reduce the high cost of vertical boreholes. There are different types of HGHE configuration: slinky, spiral and linear[2]. But these kinds of exchangers are particularly sensitive to atmospheric fluctuations and soil moisture dynamics, because they are installed at shallow depths [3]. In this context, a 3D transient numerical model based on the finite element method using "COMSOL Multiphisics" software was established to evaluate the interaction between the atmosphere-ground-heat exchanger and the temperature distribution in the ground.

2. Experimental

The work concerns a numerical study of the performance of shallow heat exchangers in the heating and cooling of buildings in the city of Mostaganem. The numerical model includes the following components: the climatology of region (ambient temperature, wind speed, rainfall and solar radiation), the atmosphere-soil-heat exchanger interactions, water transfer in unsaturated soils, thermal properties of the site soils, heat transfer in unsaturated soils and heat transfer in pipes.

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3. Results and Discussion

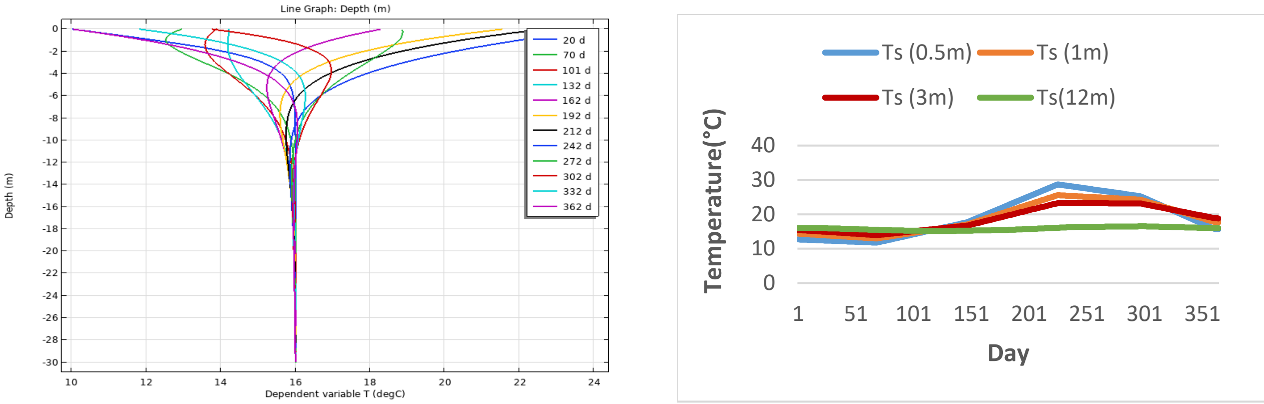

Fig. 1- Soil temperature prof

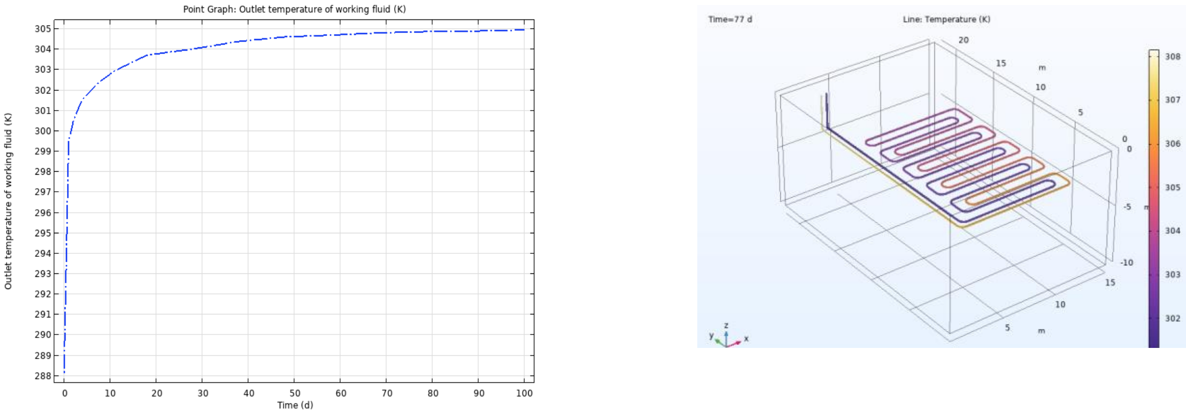

Fig. 2– fluid outlet temperature for a slinky heat exchanger

4. Conclusions

Ground temperature at shallow depths, up to 12 meters below ground level, is affected by daily and seasonal weather cycles. However, at depths greater than 12 meters, the ground temperature remains relatively constant. This relatively constant temperature means that buildings can be heated and cooled on a long-term basis.

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