Study for cooling or heating of a local in southeastern Algeria by geothermal energy

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***Abstract*— Energy consumption in arid areas is very high due to the high temperature in the summer and the low temperature in the winter. The local cooling necessities a considerable consumption of electric energy, which costs very expensive. The warm-up also consumes energy (city gas or other fossil fuels). In our study, we show that geothermal energy is a favorable solution, very simple, economical and non-polluting. For this, an air-to-ground plastic exchanger of 45 to 50 meters, with a maximum depth of 3 meters is used to cool and heat a room in an arid zone (south-east of Algeria). When the ambient temperature varies between 34 and 40 °C, the cooling temperature varies between 25 and 28 °C. These values are quite acceptable with minimal consumption of electrical energy**.

Keywords*— *cooling, heating, exchanger, geothermal energy

I. Introduction

This document is a template. An electronic copy can be downloaded from the conference website. For questions on paper guidelines, please contact the conference publications committee as indicated on the conference website. Information about final paper submission is available from the conference website. The utilization of geothermal energy to reduce heating and cooling needs in buildings has received increasing attention during the last several years. An Earth Air Tunnel Heat Exchanger (EATHE) consists of a long underground metal or plastic pipe through which air is drawn. As air travels through the pipe, it gives up or receives some of its heat to/from the surrounding soil and enters the room as conditioned air during the cooling and heating period.

Kabashnikov et al [1] developed a mathematical model for calculating the temperature ofthe soil and air in a soil heat exchanger for ventilation systems. Moummiet al[2] have established theoretical and experimental study on refreshing by geothermal energy in Biskra area. Benhammou et al [3] presented study on simulation and characterization of a geothermal air exchanger for refreshing buildings operating in the climatic conditions of southern Algeria (Adrar) A.Trombe et al. [4] proposed a numerical model to evaluate the performance of this system when it is coupled with an individual house; the results were compared with experimental model. They also proved that this system can be used to save 10% of house energy consumption by preheating fresh air in winter, and to improve comfort conditions in summer V. Bansal et al [5,6] developed a CFD model to determine the effect of air velocity and buried pipe material on the performance of EAHE system. A. Atia et al [7] Has been studied aims to give an overview of the implementation of the ground heat exchanger (GHE) for passive air conditioning As used the soil as a source of heat; These factors have the greatest influence on the performance of GHE, which must be considered from the thermal properties of the soil to the piping materials. In addition, a review of the literature on major scientific research implemented in low temperature geothermal energy such as the Algerian climate, to reduce energy needs and greenhouse gas emissions. M. Bojic et al [8] presented a technical and economic studies of an EAHE coupled to the system for heating or cooling of a building. D. Belatrache et al [9] studied the modeling and simulation of an air-to-ground heat exchanger (EAHE) in Adrar region, where he arrived the EAHE used in this study presents a potential for maximum daily cooling power and energy savings for cooling over a period of one year. The results obtained are very promising for small scale residential buildings. Our work is based on a CFD Fluent simulation study with real conditions in the El Oued region of southeastern Algeria. It is shown that the length of the exchanger and the depth of the exchanger location have a direct influence on the efficiency of our system.

II. MATHEMATICAL PROCEDURES

A. Computational domain

The physical domain configuration considered in this study is presented in Figure 3. The EAHE system contains four parts with a total length of 45 m. It has tubes inner diameter of 80 mm. The assembly is fixed at a depth of 3 m. The tubes are arranged and spaced from each by a center distance of 50 cm. The main source of energy is solar energy; this energy varies from one season to another. This variation influences directly or indirectly the energy systems and therefore affects our device [10].

B. Hypothesis

The physical description of EAHE system becomes very complicated. Therefore, it is appropriate to make a number of assumptions for arriving at a correct calculation time and also without losing too much information. The choice was therefore focused on a two dimensional field, and the assumptions used in this work are:

- ✓ Soil is considered homogeneous;
- ✓ A uniform temperature is assumed along the perimeter of the face of pipe;
- ✓ The temperature of the inlet air exchanger is the temperature of the outside air;
- ✓ The fluid is assumed viscous "and Newtonian;
- ✓ The flow in steady state.

We present the results of the numerical simulation obtained by the code FLUENT considering the following thermo-physical properties of air Table 1

TABLE I
PROPRIETES PHYSIQUES DE L'AIR

La masse volumique (kg/m^3)	La capacité calorifique (J/kg .K)	La conductivité thermique (W/m .K)	La viscosité dynamique kg/m .s
1.225	1006.43	0.0242	1.789e-05

The geothermal air / ground heat exchanger, studied at a depth of 3 m. the characteristics of the exchanger are present in Table 2

TABLE II
Characteristics of polyethylene high density heat exchanger

Material	PVC
Length (m)	50
Depth (m)	3
Diameter (m)	0.08
Thickness (m)	0.5
Conductivity (W m^{-1} K^{-1})	0.48

The configuration described below can be further simplified by considering a uniform airflow inside the pipe. The surrounding soil is considered to have uniform and constant thermal properties, the dimensions and physical properties of the pipe are considered constant. The monthly maximum and minimum temperatures used in the simulation of the site under study are shown in Table 3

TABLE III:
MONTHLY MAXIMUM AND MINIMUM TEMPERATURES
OF THE SITE IN EL OUED [11].

Monthly	Minimal ambient air Temperature (c)	Minimal ambient air Temperature (c)
January	5,1	18,8
February	6,8	21,1
March	11,0	25,8
April	15,3	30,4
May	19,7	34,9
June	24,8	40,3
July	28,2	43,7
August	27,5	42,8
September	23,5	37,7
October	17,6	32,2
November	10,5	24,2
December	6,0	19,2

C. Method and experience

On the one hand, the Fluent CFD was used to bring us the influence of the length and position of the exchanger in the ground, on the efficiency of our system. The speed is set at 10 m / s. on the other hand, real experience has been established to validate this study.

Figure 1 shows the relationship between the outlet temperatures as a function of the length of the exchanger (m). Each time the length increases, the output temperature decreases. Note that this temperature is constant when the length exceeds 45 meters. Figure 1 shows also the exchanger made by CFD Fluent.

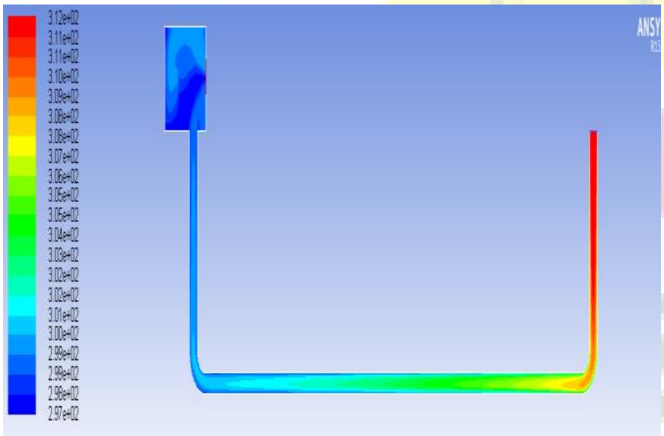

Figure 1.*Temperature distribution in the exchanger theexchanger length and velocity*

III. Results and discussion

Figure 2 shows the soil temperature of the EL Oued region at different depths (1-5 m). With an increase in the underground depth, the fluctuations of the sine wave of the soil temperature decrease until the temperature reaches a relatively constant value at 5 m depth, which allows us to use the soil as a source of heat for heating and cooling of the air

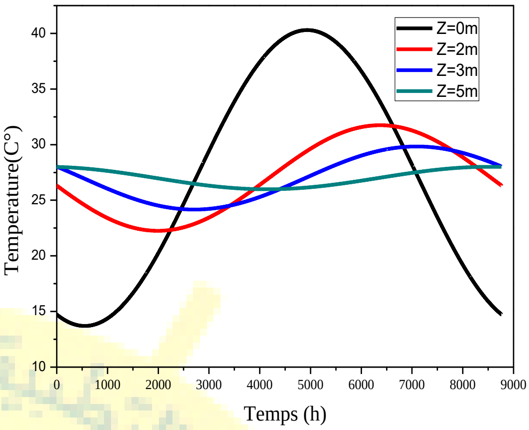

Figure 2. *Soil temperature in the region of EL Oued at different depths*

Figure 3 shows the relationship between the air temperature in (° C) exiting the heat exchanger in PCV as a function of the length of the same exchanger (m). The diameter of the tube, the thickness are fixed and we stabilize the speed of the area which circulates in the exchanger at V = 10 m / s. The measurements are taken every hour with thermocouples K1 type.

It's noted that the temperature degrades from 38 ° C at the beginning of the experiment to 24 ° C at the end of the experiment. Each time the fluid (air) advances in the tube with a constant speed, it pertains to the heat. Arriving at 42 meters we notice the air temperature stabilizes between 24 and 25° C. This temperature is very pleasant for the human being in the period of the winter or the ambient temperature varies between 04°C the night and 14 °C during the day. It is also suitable for enrichment of a room during the summer period where the ambient temperature varies between 25 °C night and 45 °C during the day.

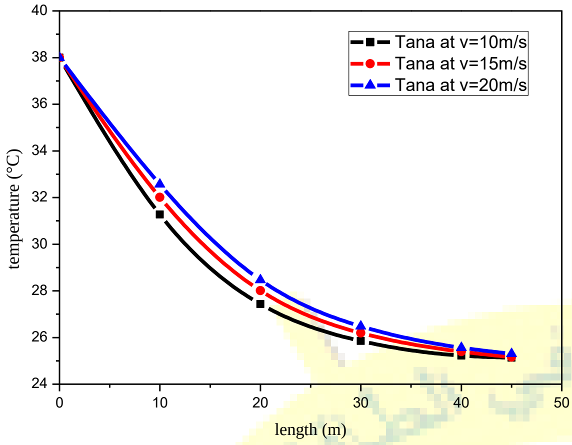

Figure 3. *Variation of the air temperature versus*

Figure 4 shows the experimental result is validated by a CFD simulation and we note that the two graphs have the same shape and they are almost similar with a temperature difference that happens at 2°C, which is even acceptable.

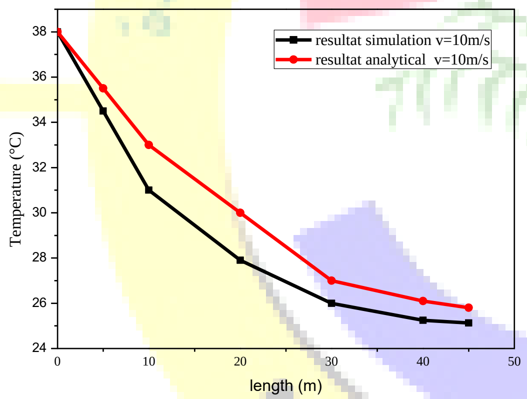

Figure 4. Validation With the experience

IV. Conclusions

Based on our work, we should not exceed the length of 50 meters for the exchanger and not to exceed the depth of 3 meters in the ground. The simulations resultant carried out on this CBGHE, which have 50 m long and at velocity of 10 m/s shows as described in resultant.

We found that the corresponding temperature differences between the ambient air and the cooled air at the outlet of the exchanger for inlet air temperature of 42°C and 33.4°C are respectively 13.9°C and 7.6°C. This is due to the fact that when the temperature of the ambient air is greater than that of the outlet the exchanger.

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