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Experimental Study of Air Temperature under collector and inside chimney of a SCPP Prototype Installed in Tiaret, Algeria

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***Abstract*— A prototype solar updraft power plant has been built in the Tiaret University, Algeria. The collector has a circular shape with diameter 3m . The chimney diameter is 0.11 m and it is 6 m tall. fourteen temperature sensors were installed inside the collector to measure air temperatures in different points along the collector. Practical data were recorded every five seconde for 24 hours in three months April , May and June to investigate the temperature changes in the collector and the chimney. The air temperature increased to reach a maximum value of 72.6°C which generates an updraft velocity in the chimney with a maximum value of 2.75 m/s.**

As a result of this experiment, it is obvious that any change in the solar radiation and the ambient temperature has a direct impact on varying the air temperature between the collector outlet and the ambient. It was also noticed black plastic (ground) emits most of stored thermal energy.

***Keywords*— Collector, Solar chimney, Temperature, Sensor.**

I. INTRODUCTION

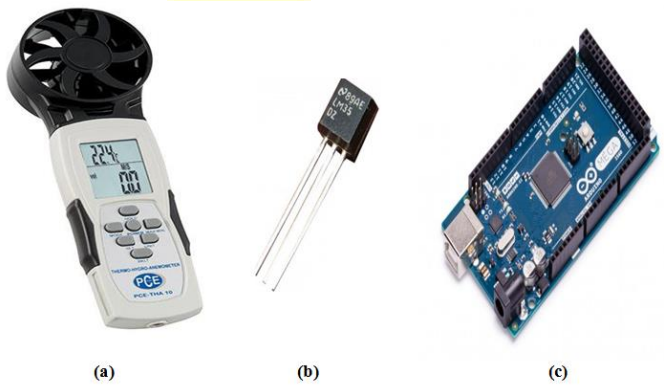
The solar chimney power plant (SCPP) is a technology allowing the conversion of solar energy into electricity. The power station with a solar chimney consists of three essential components, the collector, the chimney or the tower and the turbine. SCPP is power plants that use the force of an ascending draft. The greenhouse is heated by the solar rays, the hot air becomes lighter than the surrounding air circulates until worms the tower while passing by turbines, those transform the energy of the flow of air into mechanical energy and actuate generators to produce electricity. The first prototype experimental work in the solar chimney power plant was built in manzanares , spain in 1982, by a German structural engineering company, Schlaich Bergermann , the plant had a collector diameter of 244 m and 194.6 m height , 10 m diameter of chimney , to produce 50 kW peak [1] . This prototype was in operation from 1982 to 1989. In 1983 Krisst et al [2]. Built four pilot SCPPs, including a “backyard type” device with 10 m high chimney, 6 m collector base diameter and a power capacity of 10 W in West Hartford. Turkey in 1985 , Kulunk [3] built a micro prototype with structural parameters of 0.14 W with a solar chimney 2 m high, 7 cm in diameter and a 9 m2 collector. Pasurmarthi and Sherif [4] ; [5] in 1997 , built for solar chimney power in florida to assess A demonstration model its theoretical and experimental Two experimental modifications were tried on the collector: (1) extending the collector base and (2) introducing an intermediate absorber. In china, Zhou et al [6] was built A small pilot experimental solar chimney consisted of an air collector 10 m in diameter and an 8 m tall chimney. The temperature distribution in the solar chimney power setup was measured. In 2011 Kasaeian et al [7] making a solar chimney pilot power plant with 10 m collector diameter and 12 m chimney height, the temperatures and air velocities were measured, in the campus of the University of Zanjan, in Iran. This unit is (40 m × 40 m) square. [8] so , this study present economic analysis and effective parameters to optimize the solar chimney performance. A solar updraft tower consists of an air collector 1.4 m in diameter and 80 cm tall chimney was set up in NIT Hamirpur, Himachal-Pradesh, India. [9] The objective of the study was to investigate the variation of velocity with essential geometric parameter of the system. In Jordan was built by Al-Dabbas [10] (2011) the pilot solar updraft tower power plant model system .the small project height of chimney 4 m, radius 0.29 m, plastic solar collector area 36m2 , collector roof height 1m, wind turbine that was a compensation of the suction fan with a diameter 0.5m , and a small generator 6V The experimental results in this paper show that the maximum height (Hmax) gradually increases with the solar irradiation (G). Also, in the same way, with the pressure difference (p) increases with solar irradiation. The small pilot which was constructed of SCPP at University of Tehran in 2014 [11] the height of chimney 3 m , and collector radius of 3 m , many studies achieve , the first Research provided An analytical and numerical study for geometrical

optimizing of a solar chimney next study Presented with the Experimental study of geometrical and climate effects on the performance of a small solar chimney in 2015 [12]. In 2016, the search for the same prototype continued an experimental study on the thermal performance of a solar chimney with different dimensional parameters [13]. In this paper, the prototype has been built and experimentally analyzed. Data were collected from inside Collector and chimney for three months during better condition of weather to investigate the system performance in this period.

II. PROTOTYPE SET-UP

In order to analyze the air temperature a pilot experimental prototype was constructed in Tiaret, University. For simulate the actual conditions of the ground (soil) in using black plastic .The collector has a circular shape with a metallic framework, which was covered by polyethylene sheets.

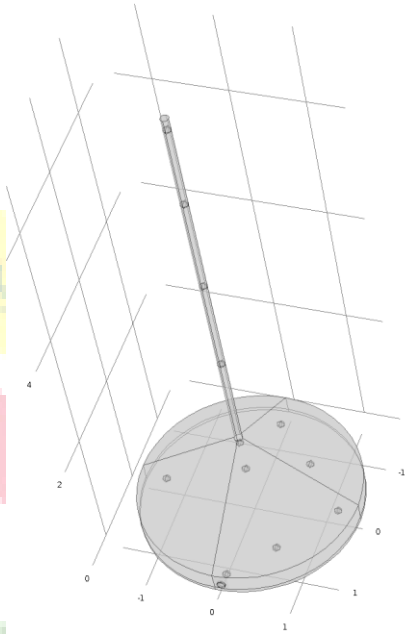
The PVC pipes that are 6 m long and 0.11 m in diameter (**Figure 1**). The LM35 is an integrated –circuit temperature sensor with an output voltage which is linearly proportional to the Centigrade temperature. The LM35 is rated to operate over a 55°C to +150°C temperature; it has very low self-heating, less than 0.1°C in still air.(**Figure 2**). The thermo-Hygro-Anemometer PCE-THA 10 was used to measure temperature, humidity and air velocity with the included software and USB cable to computer (**Figure 3**).



(a) (b) (c)

III. LOCATION OF THE SENSORS INSIDE THE COLLECTOR AND FOR THE CHIMNEY

The Temperature measuring of the air under collector and in the chimney, we used (14) thermal sensors planted in the collector and chimney as shown in (**Figure 4**) .



IV- RESULTS AND DISCUSSION

Performing this study of experimental air temperature, we selected one day of May, 27th 2017. The climatic condition are used ideal, the ambient Temperature T=39(°C), the wind speed V= 1.11 (m/s), Humidity level H=30% and Pressure P=1018 (hPa) at 12 pm.

A. VARIATION OF THE AIR TEMPERATURE INSIDE THE COLLECTOR

Only the data of one days are illustrated. The data measured from the early morning of May 27 th, 2012 to the early morning are depicted in (**Figure 5**) and (**Figure 6**) . These 2 sensors were chosen T3 and T6 among 8 sensors, to present the maximum temperature difference recorded during the whole experiment inside the collector. Experimental results ambient temperature and air temperature are illustrated. The data of solar radiation are taken from web site Algerian portal of renewable energy [site cder] .

When the sun rises , the air temperature inside collector increases gradually as solar radiation increase by the the free convectional heat transfer , hot air moves toward the chimney .The solar radiation increased progressively recording a maximum data of 1071Wh/m^2 at 11:58 in sensor T3. The air temperature was fond 72°C , the ambient temperature was 39.1 °C.

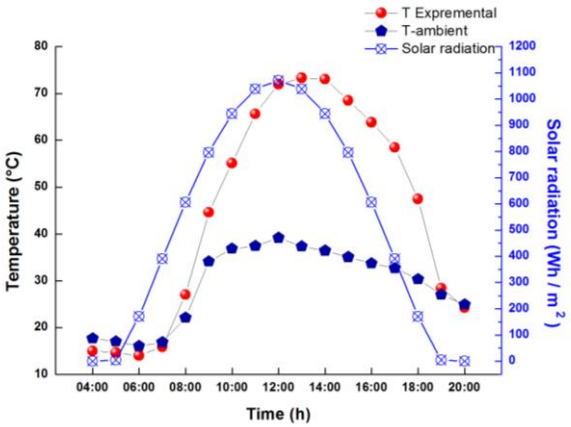


Fig.5.variation solar radiation, ambient temperature and air temperature in sensor T3

In sensor T6 ,solar radiation and ambient temperature are the same with those found in sensor T3, so the air temperature was 66.5°C.

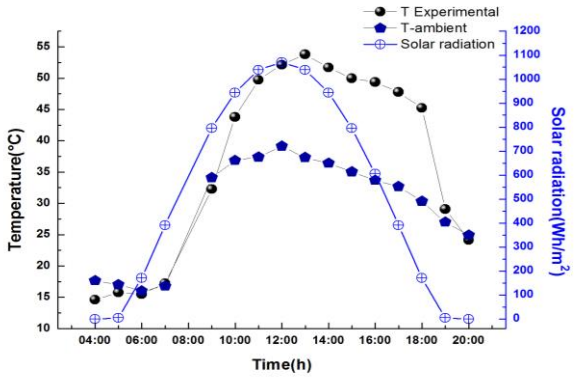


Fig.6.variation solar radiation, ambient temperature and air temperature in sensor T3

The maximum air temperature difference between T3 sensor and the ambient was 32.9°C . During the period from 11h to 13h , solar radiation reduced values greater than 1000 Wh/m^2 , of its peak value while the air temperature inside the collector almost upper 60°C. Most of the thermal energy stored from the morning in the black plastic soil was emitted back to heat the air underneath the collector.

Difference between T6 sensor and the ambient temperature was 27.4°C, indicate that there is a gradient of the temperature between T3, T6 and the ambient temperature and its signify an air flow towards the chimney .

B. VARIATION OF THE AIR TEMPERATURE AND AIR VELOCITY IN THE SENSOR T8

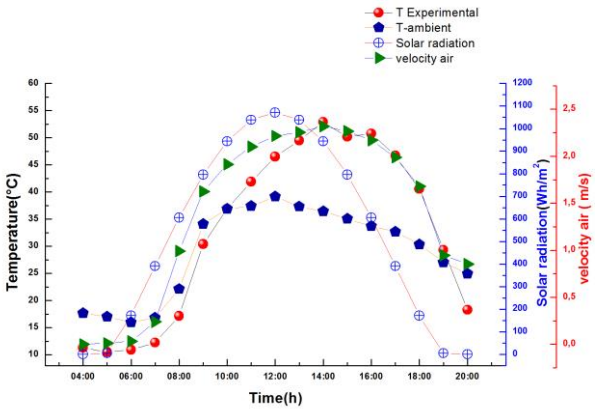


Fig.7.variation solar radiation, ambient temperature, air velocity and air temperature in sensor T8

The changes in the air temperature were measured and recorded in sensor T8, which is point (figure 7). From sunrise till noon, the maximum readings were recorded in T8 sensor between 11h and 13h. In the afternoon, taking into account that the solar radiation was minimal, the black plastic soil emitted a large amount of stored heat back to the air underneath the collector via free convection and radiation causing a continuous decrease in temperature observed from noon up to sunset. During nighttime, temperature will continue to decrease and it was noticed that air temperatures were constant. This indicates that the convection heat transfer rate from the air temperature is higher. The changes in air temperature in the vertical direction from inside the collector to the chimney. The maximum air temperature recorded was 46.5°C, in solar radiation take great value 1071 Wh/m^2 , ambient temperature was 39.1°C, the air velocity was fond 2.2m/s.

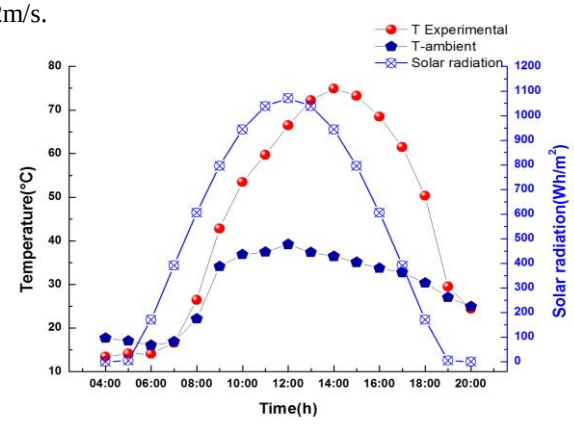


Fig.8.variation solar radiation, ambient temperature and air temperature in sensor T9

C. VARIATION OF THE AIR TEMPERATURE IN THE CHIMNEY

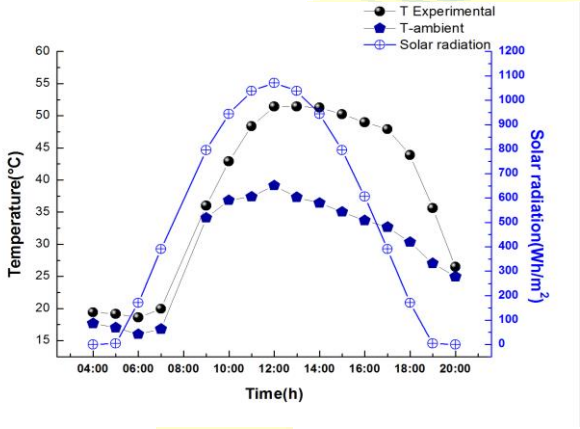


Fig.10.variation solar radiation, ambient temperature and air temperature in sensor T11

The (**figure 9**) and (**figure 10**) shows the air temperature in chimney. The solar radiation increased and recording a maximum data of 1071Wh/m^2 at 11:58 in sensors T9 and T11. The air temperature was fond51.1°C,51.4°C the ambient temperature was 39.1 °C and solar radiation was 1071Wh/m^2. The difference between air temperature under the collector and in the chimney are creating an artificial wind because there is gradient of the temperature .

V.**CONCLUSION**

A pilot solar chimney power plant was erected in Tiaret University. The prototype was analyzed the variation air temperature inside the collector and in the chimney.

In this study, the air temperature in the collector and the chimney, hence leading to the following conclusions:

1- Although the experiment was done in hot weather, the greenhouse effect was enough to produce temperature difference between the chimney inlet and the ambient. This produced a 2.2 m/s air velocity in the chimney.

2- Solar radiation has direct impact on the prototype. The higher the radiation, the higher the chimney inlet temperature .

3- Ambient temperature changes affect inside collector and in the chimney air temperature. However, it was noticed that the impact of ambient temperature changes on the chimney inlet temperature will be minimal during the noon period .

4- Temperature difference was observed between the collector outlet and the chimney inlet . The higher the collector outlet temperature, the greater the losses. the collector outlet with the chimney inlet will improve the efficiency of the system.

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