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Design and Construction of Cooling System using Solar Furnaces and Solar Panels

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Abstract
Considering the need for cooling systems, the geographical location of Iran with very hot cities, and exhaustible fossil fuels, it is necessary to design and manufacture a cooling system that can operate using renewable energies such as solar energy. The designed system is composed of several sectors including electronics and control circuits, photovoltaic system, absorption cooling system, and parabolic solar furnace. What makes this system distinguished from other systems ever made is electronic and control circuits and utilizing 100% of the solar energy. According to the results, the final price of a split air conditioner operating with solar energy which can cool down a room with dimensions of 3×4×2.40 meters in 1 min and 50 s from 35 °C to 21 °C will be 95,880,000 IRRs. If such a system cools down such a room in 3 min, the price will be 36,720,000 IRRs. Therefore, considering the final price, we can neglect the time spent to reach the optimum temperature.
Keywords: absorption cooling system, photovoltaic panel, parabolic solar furnace, control circuit.

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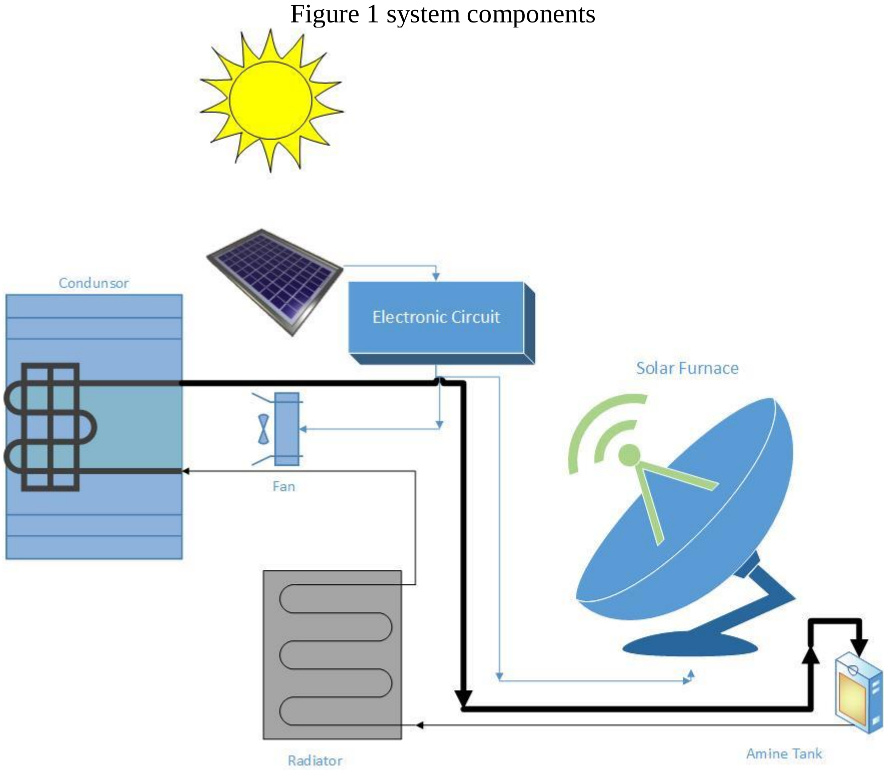
Introduction

According to the studies, people efficiency at temperature of 21°C is about 10% more than higher temperatures. This reflects the importance of air conditioning in workplace and living environment [1]. Air conditioning has two elements of cooling and heating. Since in Iran cooling systems are required more than heating systems, the focus of this study is on cooling systems. High consumption of fossil fuels in cooling systems reduces the tendency to use these systems. The objective of this study is to eliminate the use of fossil fuels in cooling systems which is fulfilled. In this regard, the solar energy is used both directly and indirectly. Solar energy is concentrated in the focal chord of parabolic solar furnace and warms up the generator of the absorption cooling system through oil-carrying copper pipes located in the center of the furnace (direct use). This heat warms up the evaporator[1] . The heat generated by the evaporator is transferred to the environment by the fan. The photovoltaic panels will provide energy required by the fan (indirect use) [2, 3].
Figure 1 shows the components required by the system to operate.

Figure 1 system components



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2. Cold Production

For cold production, an absorption cooling system was used in this article. The absorption system operates based on absorbent and refrigerant which were water and ammonia in this study, respectively. Water-ammonia mixture is heated in generator [2] and converted into vapor. In the path of the hot vapor, there is a separator[3] that separates drops of water from ammonia vapor and returns it to the ammonia-water reservoir. Figure 2 shows these components [4].

[1] Where the liquid ammonia is converted to gas then enters the refrigerator to cool it down.
[2] Where the liquid ammonia is converted to gas.
[3] Separating ammonia from the water.

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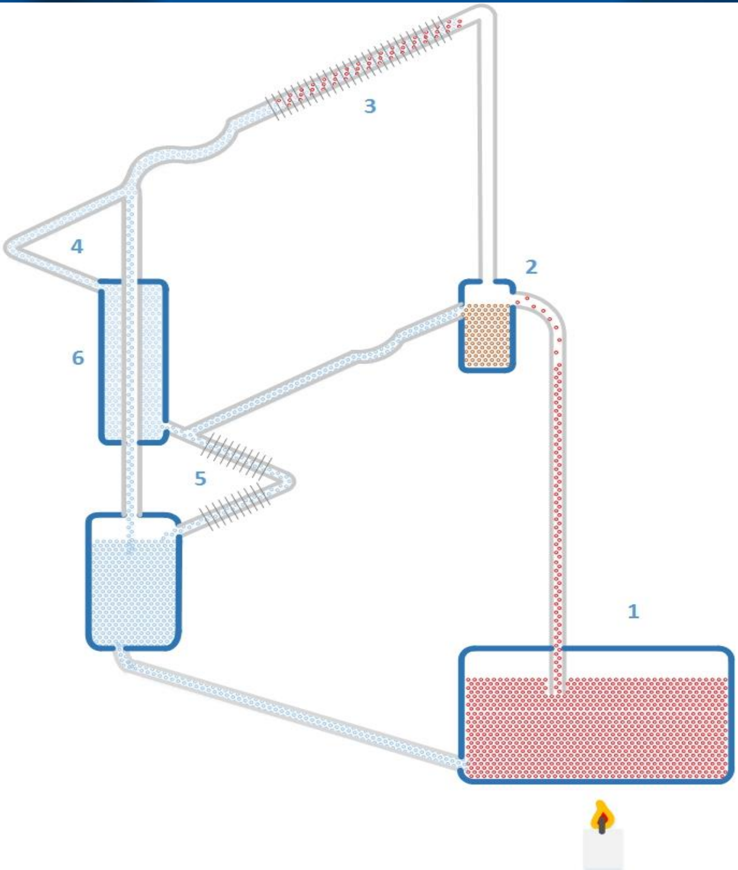

Figure 2. Absorption system: 1. generator. 2. Separator. 3. Condenser. 4. Evaporator. 5. Absorber. 6. Heat exchanger.

Then the temperature of ammonia is reduced in condenser[4] and is exposed to hydrogen in the chamber, as a result, it is quickly vaporized. For the evaporation, ammonia absorbs the heat inside the refrigerator space (evaporator). Finally, the refrigerator is cooled [5-8].

2.1. Production of Heat Required by Generator

To produce heat, a parabolic solar furnace was used in this study. To this end, the solar water-heater pipe was located at the center of furnace focal chord. The oil-carrying copper pipe passes through the solar water-heater pipe and is twisted around the generator. In this way, the maximum heat transfers from the sun to water-ammonia solution. In fact, sunlight warms up the water inside the heater and the heat is transferred to the generator by oil-carrying copper pipes. The heat transferred to the generator triggers absorption cooling system, and shortly after this, temperature is reduced to the desired level. Here, we need another approach to transfer the cold to the environment.

2.2. Temperature Transmission

To transfer the cold to the environment, a 12 V and 4 mA fan is used which can move the cool air to the environment. This fan works at two different speeds that was switched automatically depending on the ambient and the system temperature or, if necessary, it turned off. The fan voltage at different motor speeds was measured 8.8 and 2.9.

Except for fan that transfers colds to the environment, a pump was needed for ease of oil flowing that can transfer the heat generated in copper pipe as much as possible to the generator of the absorption cooling system. The pump turns on and off automatically according to the temperature of the oil in two different speeds. Pump voltage and current were 12V and 4 amps, respectively.

3. Electronic Circuits

The key elements of the designed system are electronic and control circuits because the first step to launch the system is to cool down the generator of cooling system to the desired temperature. This is

[4] Where the condensed hot ammonia gas is makes the ammonia liquid and cold.

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done by temperature control and timer circuits and triggering the oil pump. A schematic view of the system is shown in Figure 3.
The operating frequency of IC NE555, and off and on times are calculated using Eqs. 1, 2, and 3, respectively [9].

$$f = \frac{1}{\ln(2).C.(R_1 + 2(R_2 + R_{NTC}))} \quad (1)$$

$$Low = \ln(2).C.(R_1 + 2(R_2 + R_{NTC})) \quad (2)$$

$$High = \ln(2).C.(R_2 + R_{NTC}) \quad (3)$$

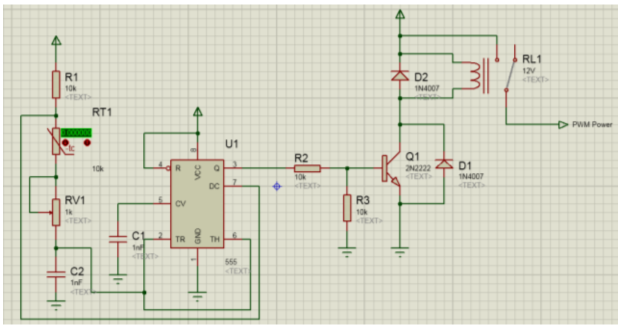
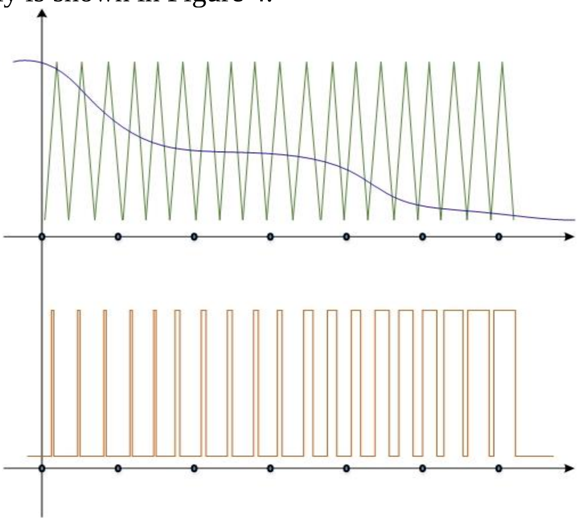


Figure 3. A schematic view of timer circuit

The air leaving the fan is the air cooled by evaporator. Therefore, fan motor speed needs to be controlled according to the ambient and evaporator temperature. The PWM circuit used in this study that did this work accurately is shown in Figure 4.


Graph 1. Circuit performance

The performance of the circuit shown in Graph 1 includes 4 op-amps [10]. In the first op amp, a reference DC voltage was generated for comparison. Using the two other op-amps (i.e. square wave generator and integrator), a triangular wave was generated. In the end, the last op amp was used for comparison purposes to generate a PWM wave.

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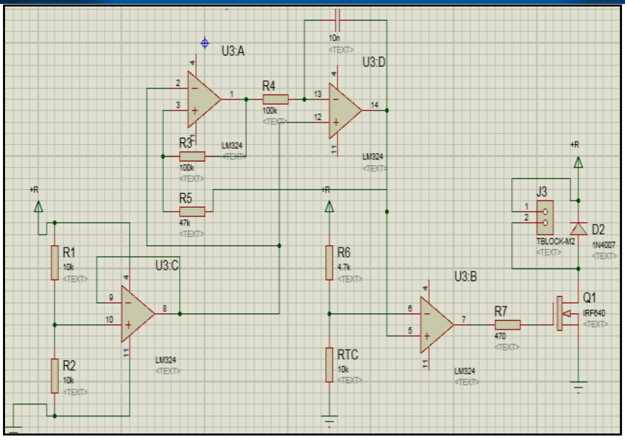


Figure 4. A schematic view of PWM circuit

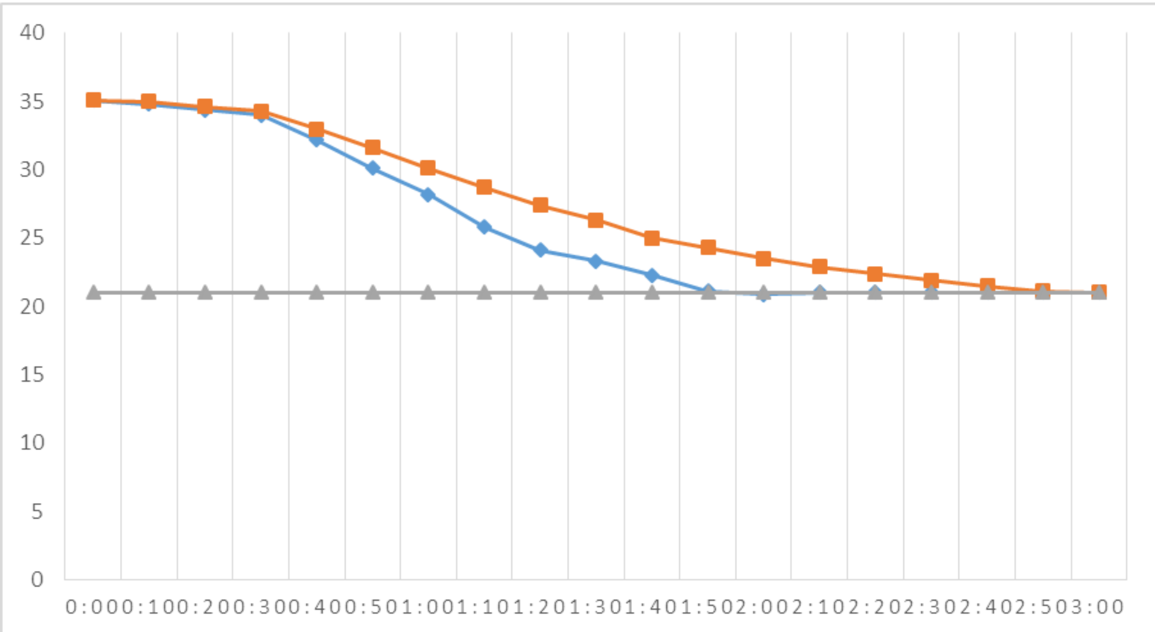
To trigger the circuits discussed in this section, a power supply is required. For this, a power circuit was used.

4. Photovoltaic Panels

Photovoltaic systems convert sunlight energy directly into direct current (DC) by solar cells [11, 12]. To supplying the power required by electronic circuits and to set up fans and oil pumps, system needs electrical energy. Since this article was seeking to eliminate fossil fuels, part of the energy was supplied through the solar energy produced by a 60-watt photovoltaic panel.

5. System Outputs

To test the proposed system performance, a 3×4×2.40 m room was used and the system was located on the roof.



Graph 2. Output of the system compared to the split air conditioned working with solar energy Gray line shows acceptable temp, blue line shows split unit work and orange line shows this system work

The designed system was compared with a split air conditioner from two points of view: cooling efficiency, and economy. Results obtained from comparison of the two systems are plotted in Graph 2 to facilitate the comparison.

6. Conclusions

Without application of electronic and control circuits, we would fail to fulfill the defined objectives. The simplicity of the proposed system in implementation, compared to other systems, is the key factor

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contributing in mass production. In terms of the cost, it can be argued that final price of this system is one thirds of other systems. In other words, paying a certain price, we can take advantage of the proposed system three times higher than other systems.

According to the results, the final price of a split air conditioner operating with solar energy which can cool down a room with dimensions of 3×4×2.40 meters in 1 min and 50 s from 35 °C to 21 °C will be 95,880,000 IRRs. If such a system cools down such a room in 3 min, the price will be 36,720,000 IRRs. Therefore, considering the final price, we can neglect the time spent to reach the optimum temperature.

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