IJMSIT

International Journal of Multidisciplinary Studies and Innovative Technologies

Volume : 2
Number: 1
Year: 2018
Pages: 05-07

Design, Analysis and Prototyping of the Combined Heating and Cooling System with Solar Energy

Osman İPEK[1], Sedeeq ALOMARI [2*], Barış GÜREL[3], Mehmet KAN[4] and Mohammed ALKHALIDI[5]

[1]Mechanical Engineering, Süleyman Demirel University, Isparta
[2]Mechanical Engineering, Süleyman Demirel University, Isparta*
[3]Mechanical Engineering, Süleyman Demirel University, Isparta
[4]Mechanical Engineering, Süleyman Demirel University, Isparta
[5]Mechanical Engineering, Süleyman Demirel University, Isparta
[*](sedeek.alomari@yahoo.com)

Abstract – Absorption cooling and heating systems are one of the most important solar energy applications. Especially if it is used for both heating (winter months) and cooling (summer months. In this study, prototype design and manufacture of a system that can be used for cooling and heating at the same temperature as the solar energy absorption system, which is used as an ammonia refrigerant, was experimentally investigated in order to avoid using an environmentally harmful fluid. Experiments were conducted between 1-31 August 2016 to see the cooling performance of the system and between 1-31 March 2017 to see the heating performance. According to the experimental results obtained, the COP value and the temperature of the room were determined. The solar-energy heating-cooling system is operated for heating purposes; the temperature of the conditioned room is reduced from 19 °C to 31 °C, while cooling is reduced from 39 °C to 23 °C. The generator temperature is measured as 89.1 °C in the summer and 57.4 °C in the winter months when the need for cooling is required. In these conditions, the COP values for cooling and heating of the combined system were found to be 4.621 and 3.283, respectively.

Keywords – Solar energy, Heating and cooling (Combined), Absorption system

I. Introduction

In the world, our energy demand is produced from sources primarily from fossil fuels (coal, oil and natural gas etc.) The use of fossil fuels and electric in the world is increasingly is also increasing. This is not only the more pollution of the environment, causing resources to run out more quickly. that are non-renewable and limited in supply and sources from alternative energy that are making progress such as solar energy, wind power and moving water. Some estimates claim that our crude oil and natural gas reserves will be depleted within next 50 years; however, another problematic issue is the side effects of using fossil fuels that combustion of them is considered to be the number one factor for the release of greenhouse gases. Further- more, population growth is another very important factor as it will almost reach nine billion people over the next 50 years. The world's energy demands will increase proportionately, energy shortage associated with environmental issues will be important for replacing fossil fuel energy production with renewable clean energy supply.

Increasing living standards and demand for human comfort has caused an increase in energy consumption. According to the International Institute of Refrigeration in world, the amount of electricity production from different types of refrigeration and air conditioning process is approximately 25% of all the electricity produced in the world. On the other hand, electricity consumption for air conditioning systems has been estimated around 60% of the whole residential and commercial buildings. For example, vapour compression based refrigeration systems consume much electricity and lead to the reduction of the valuable fossil fuel sources and production of the greenhouse gases that cause ozone layer depletion. Furthermore, some refrigerants such as CFCs, HCFCs and HFCs, which result in ozone, layer depletion, have been prohibited by the Montreal and Kyoto Protocol.

This is dangerous alternative energy sources must be sought in order to avoid the problem. Solar energy the use is ideal for solving this problem; solar energy has lots of application areas.

Solar energy might be used for air conditioning (cooling and heating systems) in two methods; photovoltaic solar cooling (conventional air conditioned based) and heat driven sorption system. The initial cost for solar photovoltaic cell is very high because the development of photovoltaic cell is very slow. Solar cooling and heating technology is environmentally friendly and contributes to a significant decrease of the CO_2 emissions which cause the greenhouse effect. Absorption Cooling and heating system is one of the most important solar energy applications. In absorption systems solar energy obtained from various energy sources, can be used directly to generate cooling and heating effect. Currently, most of the solar cooling systems commonly used are the hot water driven (NH_3/H_2O) absorption chillers. According to the operating temperature range of driving thermal source, single-effect (NH_3/H_2O) absorption chillers have the advantage of being powered by ordinary flat-plate or evacuated tubular solar collectors available in the market.

II. MATERIALS AND METHOD

The first part of fabrication the absorption cycle for cooling system consists of four major parts, a generator, a condenser, an evaporator and an absorber. These major components are divided into three parts by heat exchanger, expansion valves and a pump. Schematic diagrams of the solar-cooling system are shown in the Figure 1.

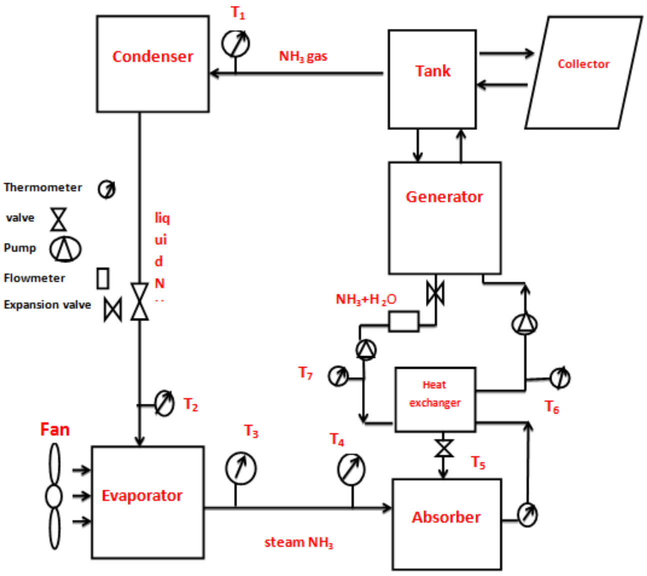

Fig. 1 Absorption cooling system

The cooling system work; the refrigerant enters the condenser at high pressure and temperature and gets condensed by natural convection and radiation. The condenser consists of iron tube and square radial fins. Than the refrigerant passes through the throttling, its pressure and temperature reduces suddenly. This refrigerant (ammonia in this case) then enters the evaporator. The refrigerant at very low pressure and temperature produces the cooling effect. This refrigerant flows to the absorber that acts as the suction part of the refrigeration cycle. When ammonia from the evaporator enters the absorber, it is absorbed by the absorbent due to which the pressure inside the absorber reduces further leading to more flow of the refrigerant from the evaporator to the absorber. At high temperature water absorbs lesser ammonia, hence it is cooled by the external coolant to increase it ammonia absorption capacity in this case the cooling done by air. In this part which generate the heat by system the Evacuated-tube collector and supply it into the refrigerant solution to raise the pressure and temperature to able it to condensation in the condenser.

The second part of fabrication, the absorption cycle for heating system consists of solar collector, tank, radiator, and fan. Schematic diagrams of the solar-heating system are shown in the Figure 2.

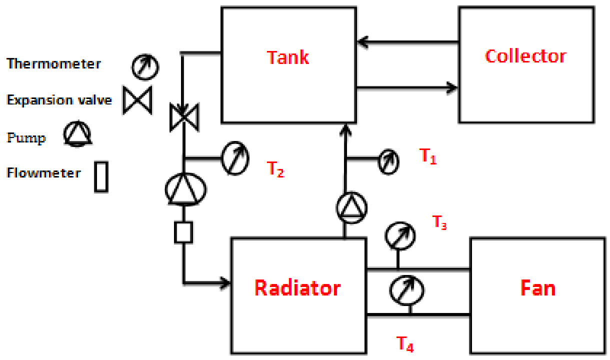

Fig. 2 Absorption heating system

The heating system work; the evacuated-tube collector receives energy from sunlight and heat is accumulated in the storage tank. The energy is transferred through the high temperature energy storage tank to the system. After the water temperature reach to 35⁰ C, the hot water move from the solar collector inters to radiator (thermal radiator). The radiator provides heating to the space to be hooted. We put fan before the radiator to push the hot air to room.

III. RESULTS

The cooling and heating can be done by using solar energy. The biggest difference of this system is that the sun directly utilizes the heating and cooling power instead of producing electricity with solar panels. The testing was performed from 9 am to 4 pm .The testing done it was noted that room temperature it became 23°C for cooling system and 31°C for the heating system. The result was noted that the collector fluid temperature increased with time and it became 89.1°C in the summer for cooling system and 57.4°C in the winter for heating system. The C.O.P of the system was obtained from the calculation as 4.021 for the cooling system and 3.087 for the heating system. The experimental studies on the absorption systems were mainly based on the coefficient of performance (COP), which is based measure to describe the quality of conversation of heat in to cold and characterize the performance of such cycle, which is defined as the useful cold Qe per unit invested driving Qg:

$COP = \frac{Qe}{Qg}$ ………..1

1. Refrigeration in the evaporator;

$Qe = Mr.Hevp$ ……….2

Where mr= the flow rate of the refrigeration, Hevp = the enthalpy of the refrigeration in the liquid vapour phase.

2. Heat flow in the generator

$Qg = Mr.Cpr.(T2 - T1) + (Mr.\Delta Hgen) + Mrv.CPrv.(T2 - T1)v$ ....……3

Where Mr = the flow rate of the refrigeration, CPr = the specific heat of liquid refrigeration, CPrv = the specific heat of the superheated vapor refrigerant, ΔHgen = the enthalpy of the refrigerant in the vapour phase, Mrv = the flow rate of the vapour of the refrigerant.

2. Heat flow in the condenser

$Qc = Mr(HcHb)$ ………4

Where Mr = the flow rate of the refrigerant, Hc = the enthalpy of the liquid, Hb = the enthalpy of the vapour.

3. Total solar radiation

$It = IDn \cos\theta + Id + Ir$ ………5

Where θ is the angle between the direction of the sun and the line perpendicular to the surface θ= 0 at noon in mid-summer, IDn = direct radiation from the sun, Id = diffuse radiation from the sky, Ir = reflected short wave (solar) radiation.

A. Direct radiation from the sun

$$Idn = 1370\exp(-0.21/\sin\beta) \quad \ldots\ldots\ldots\ldots 6$$

Formed summer

B. Diffuse radiation from the sky

$$Id = 0.135 IDn.Fws \quad \ldots\ldots\ldots\ldots 7$$

Where Fws is the view factor, defined as

$$Fws = (1 + \cos\varepsilon)/2 \quad \ldots\ldots\ldots.. 8$$

C. Reflected short wave (solar) radiation

$$Ir = (IDn + Id).FWG.\rho \quad \ldots\ldots\ldots\ldots 9$$

Where ρ is reflected from the ground = 0.6

And FWG is the angle factor defined as:

$$FWG = (1 \cos\varepsilon)/2 \quad \ldots\ldots\ldots\ldots 10$$

Table 1. Variance of collector fluid temperature with time for cooling system

SI.No	Time	COLLECTOR TEMPATURE °C
1	9:00	65.5
2	10:00	69.2
3	11:00	73.3
4	12:00	77.1
5	13:00	81.4
6	14:00	83.9
7	15:00	86.4
8	16:00	89.1

Table 2. Variance of collecter fluid temperature with time for heating system

SI.No	Time	COLLECTOR TEMPERATURE °C
1	9:00	38
2	10:00	41.1
3	11:00	45.6
4	12:00	46
5	13:00	47.6
6	14:00	50.3
7	15:00	52.4
8	16:00	57.4

Table 3. Variance of room temperature with time for cooling system

SI.NO	TIME	ROOM TEMPERATURE °C
1	9:00	39
2	10:00	38.2
3	11:00	37.7
4	12:00	32.3
5	13:00	29.4
6	14:00	27.5
7	15:00	24.1
8	16:00	23

Table 4. Variance of room temperature with time for heating system

SI.NO	TIME	ROOM TEMPERATURE°C
1	9:00	19
2	10:00	24.3
3	11:00	25.4
4	12:00	27.7
5	13:00	28.3
6	14:00	29.8
7	15:00	31
8	16:00	31

IV. CONCLUSION

The cooling and heating can be done by using solar energy. In this study the absorption cooling and heating system using the Evacuated-tube collectors was successfully fabricated.in the future it is decided to compare the performance between the absorption cooling and heating system and vapour compression refrigeration system using evacuated-tube collectors.

References

[1] Bell, I.A., Al-Daini, A.J., Al-Ali, Habib., Abdel-Gayed, R.G., and Duckers, l., The design of an evaporator/absorber and thermodynamic analysis of a vapour absorption chiller driven by solar energy, World Renewable Energy Congress ,(1996), pp. 657-660.

[2] Ravi kumar, T.S., Suganthi, L., and Anand, A.Samuel., Exergy analysis of solar assisted double effect absorption refrigeration system, Renewable Energy, Vol .14(1-4), (1998), pp. 55-59.

[3] De Francisco, A., Illanes, R., Torres, J.L., Castillo, M., De Blas, M., Prieto, E ,.Garcia, A., Development and testing of a prototype of low-power water ammonia absorption equipment for solar energy applications, Renewable Energy, Vol. 25, (2002), pp. 537-544.

[4] Lazzarin R. M. Solar Cooling Plants: How to Arrange Solar Collectors,Absorption Chillers and the Load. *International Journal of Low CarbonTechnologies* 2007 vol. 2(4), p. 376-390.

[5] Aebischer B. at al. Impact of Climate Change on Thermal Comfort,Heating and Cooling Energy Demand in Europe. *In: The ECEEE 2007Summer study*, Panel 5, La Colle sur Loup, France, 2007.