Analysis Of Solar Absorption Cooling System For Domestic Applications

B. L. Gupta[a*], Mayank Bhatanagar[b] , Jyotirmay Mathur[c]

[a] Department of Mechanical Engineering, Govt. Engineering College Bharatpur (Raj.)

[b]Energy Analyst/GRIHA Trainer Environmental Design Solutions Pvt. Ltd. [EDS]

[c] Department of Mechanical Engineering, MNIT Jaipur (Raj.)

Abstract- The increase in demand of air-conditioning has significantly increased the electricity consumption of the building. The conventional vapor compression system is main cause of high electricity consumption. The residential building has large percentage of this consumption. The high energy consumption and limited sources, leads the world to energy shortage. The solar air-conditioning system is a good replacement of conventional air-conditioning system. There are various types of solar cooling technologies namely solar photovoltaic, desiccant cooling adsorption and absorption cooling system. For residential building at New Delhi, India. Solar absorption cooling system is developed and simulated in TRNSYS with three types of solar collectors namely E.T.C, F.P.C and P.T.C. The parameter storage tank volumes and flow rate are used to study the performance of solar cooling system. 0.86 m^3 chilled water storage tank and 6.72 m^3 hot water storage tank combinations is best in all configurations with the 5372 kg/hr Chilled Water Flow Rate to cooling coil.

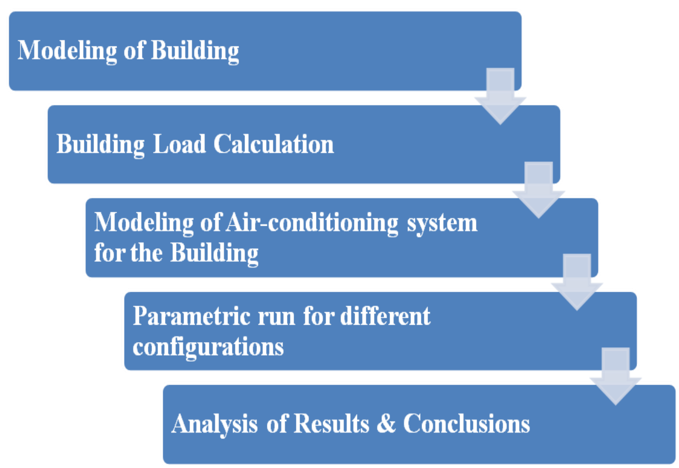
Key words- collectors, storage tank,, flow rate trnsys.

I. INTRODUCTION

In the last few years, thermal comfort in summer has significantly increased the electricity consumption in buildings. This is mainly due to the increase in the demand of air conditioning systems operating with mechanical vapour compression system. (Almshkawi, 2011) Solar thermal cooling technology offers the potential of an environmentally cleaner and a lower operating cost alternative for cooling production compared to vapour compression chiller. Despite a lower coefficient of performance (COP) as compared to the vapor compression cycle, absorption cooling systems are attractive for using because of the near coincidence of peak cooling loads with the available solar power. The application of solar power for cooling products for preservation purposes, as well as air conditioning in buildings, is a field with high potential in the coming years and as the technological setbacks are overcome, it may become a highly profitable sector. Absorption system appears to be one of the most promising methods. Many arrangements or cycles are possible: solar collectors can be used to provide energy for absorption cooling, desiccant cooling, and Rankine-vapour compression cycles. Solar hybrid cooling systems are also possible. If solar cooling can be combined with solar heating, the solar system can be more fully utilized and the economic benefits should increase.

II METHODOLOGY

It comprises of various phases of the study and description of the software used. The computer based simulation is performed for a model of solar absorption cooling system of a typical house, using TRNSYS software. The various phases are:



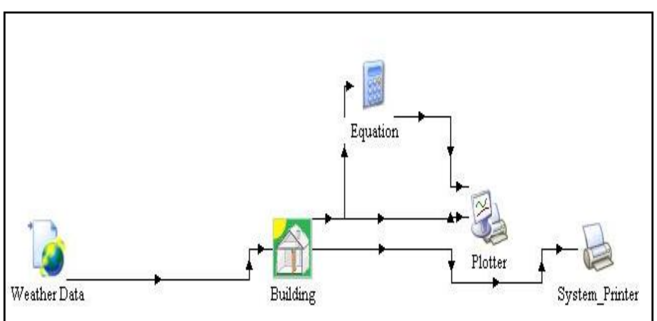
The building envelope is constructed according to the ECBC (Energy Conservation Building Code), ventilation and infiltration has been designed according to ASHRAE, and other details like lighting loads, equipment loads are according to general domestic uses. The building is modeled in TRNBuild. After modeling of the building, another model for calculation of Building's cooling load has been prepared using TRNSYS. According to the obtained building cooling load a solar cooling system consisting of a solar collector, a hot and chilled water buffer storage tank, pumps, an absorption chiller and a fan-coil unit is modeled in TRNSYS. The whole cooling system is based on thermal energy captured by the solar collector, thus three configuration of solar cooling systems are used (with or without auxiliary heat) to analyze the system. The auxiliary heating is used to minimize the unmet hours. The volumes of hot water tank and chilled water tank are used to study the performance of the system.

III BUILDING DESCRIPTION

The building being used for this work is a single family house situated in New Delhi. The building is a 24 hr. used building having 66.89 m^2 floor area. The orientation of the building is towards west. The building has 2 bedrooms, 1 living room as conditioned space. Table 4-1 presents the geometrical description. The whole building envelope is constructed according to the Energy Conservation Building Codes. The details of building are as follows:

S. No.	Space	Floor Dimensions (m)	Window Dimensions (m)
1	Living Room (Conditioned)	5.4864 x 4.8768	1.2192 x 1.524
2	Bedroom 1 (conditioned)	3.6576 x 4.2672	1.2192 x 1.8288
3	Bedroom 2 (conditioned)	3.6576 x 4.2672	1.2192 x 1.8288
4	Kitchen unconditioned	1.8288 x 2.4384	0.9144 x 1.524
5	Toilets unconditioned	1.8288 x 2.4384	-

IV COOLING LOAD CALCULATION MODEL



Cooling Load Calculation Model

In TRNSYS simulation studio, the cooling load calculation model consists of weather data and the building file which was made in TRNBuild. The composite climatic city New Delhi was used. The model consists of weather data reader (type 15), multi-zone building file reader (type 56), a plotter (type 65) and a printer (type 25). The weather file used is typical metrological file (*.tm2).

New Delhi has come into the category of Composite climate. In this type of climate zone the intensity of solar radiation is very high in summer with diffuse radiation amounting to a small fraction of the total. In monsoons, the intensity is low with predominantly diffuse radiation. The maximum daytime temperature in summers is in the range of 32 – 43 ^{o} C, and night time values are from 27 to 32 ^{o} C. In winter, the values are between 10 to 25 ^{o}C during the day and 4 to 10 ^{o}C at night.

- Latitude = 28.58^{o} N
- Longitude = 77.2^{o} E
- Elevation above sea level (m) = 216 m
- Time zone = (GMT+05:30)

V SIMULATION OF SOLAR ABSORPTION COOLING SYSTEM

The solar absorption cooling system consists of solar collector, hot water storage tank, absorption chiller, chilled water storage tank, fan coil unit and circulating pumps. The solar collector absorbs solar radiation and transfers heat to fluid which is flowing in the collector. The hot fluid (water) coming from the collector is stored in a storage tank (HWT). The hot water then flow into the generator of absorption chiller, where chiller utilizes heat to evaporate refrigerant. Then refrigerant flows into evaporator through condenser. The chilled water is flow into the evaporator and rejects its heat to refrigerant. The cooling tower is used to cool the cooling water, which is used in condenser and absorber. The chilled water coming from absorption chiller is stored in another thermal storage tank (CWT). The chilled water is used in fan-coil unit to cool the supply air at designed temperature. The fan-coil unit comprises a chilled water pump, a cooling coil and a fan. The schematic of the solar absorption cooling system is as follows

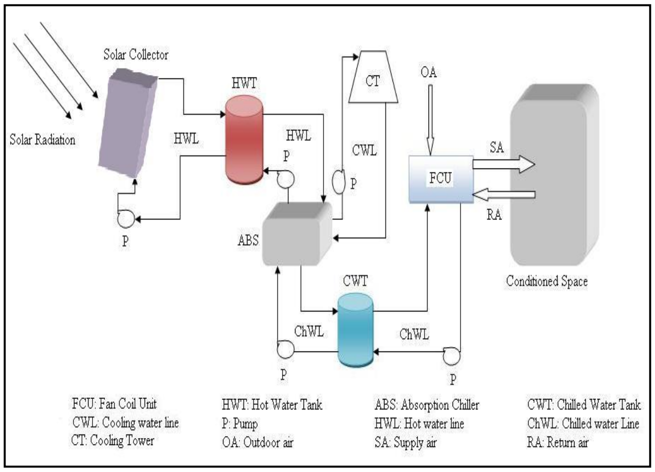
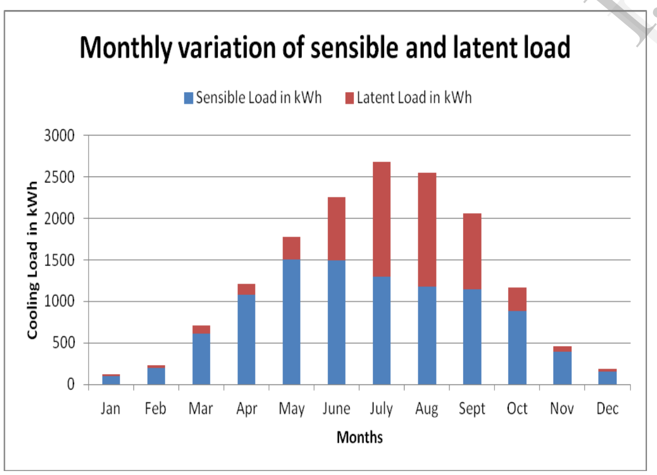


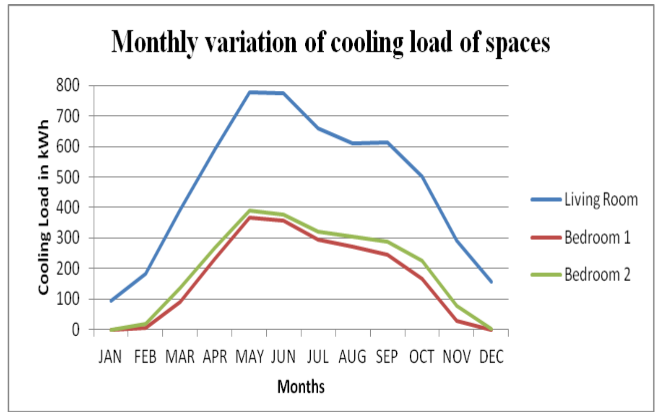
Fig: 1 Schematic of Solar Absorption Cooling system

VI RESULT AND DISCUSSION

The graph.1shows the hourly variation of sensible cooling load, latent load and combine of both. The maximum total cooling load is about 8 kW. The maximum sensible and latent load is the order of 5 kW in the month of June and July respectively. The requirement of chiller is given by the addition of 20% safety factor and 10% pipe & duct losses; therefore, here installed chiller capacity is 10 kW.



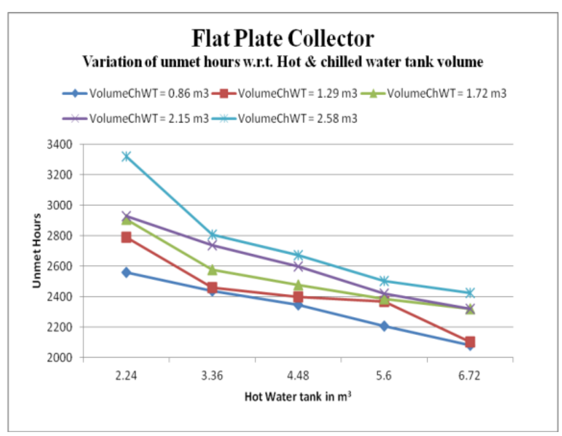
Graph: 1



Graph: 2

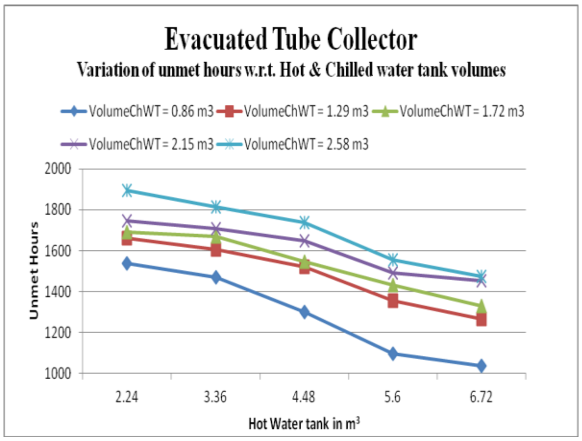
The above graph 2 shows monthly variation of cooling load for different conditioned spaces. As per the schedule of the cooling hours for living room is between 1700 -2200 hours for weekdays and 0800 – 2200 hours for weekend and for bedrooms conditioning hours are between 2200 hours to 0800 hours, therefore the cooling load constituent solar heat gain is predominant for living room as compare to bedroom. The other reasons are the difference of internal loads and orientation of the space.

The graph 3 represents the variation of unmet hours of Flat plate collector based configuration when auxiliary heating is not in consideration. As shown in the graph, unmet hours decrease with increase of hot water tank volume because when increase the hot water tank capacity due to more flow rate of collector outlet as compare to supply of hot water in chiller which increases the availability of hot water in non-sunshine hours. And in the case of chilled water tank volume unmet hours increases with the tank volume because the chilled water flow rate is same and as volume increases chilled water temperature decreases. The lowest unmet hours observed for the 6.72 m^3 hot water and 0.86 m^3 chilled water tank volume are 2081 hours.

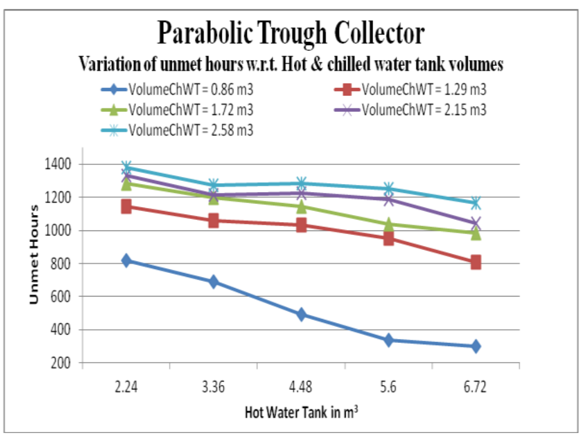


Graph:3

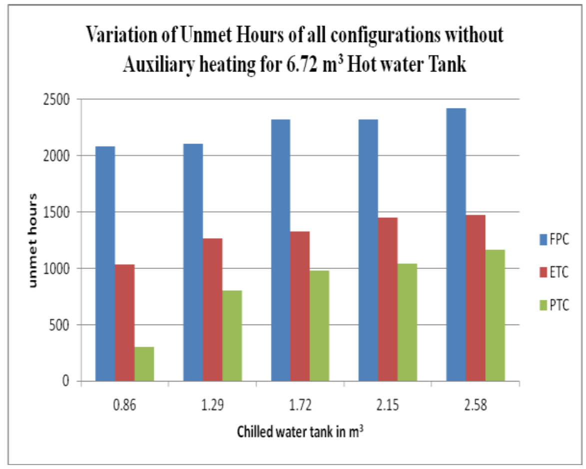
The graph 4 and 5 shows variation of unmet hours with respect to hot and chilled water tank volumes. The trend is same as flat plate collector based system. The ranges of unmet hours are between 1000 hours to 1900 hours for ETC and 290 hours to 1400 hours for PTC without auxiliary heating. The lowest unmet hours are observed for 0.86 m^3 chilled water tank volume and 6.72 m^3 hot water tanks are 1035 and 302 hours respectively for the ETC and PTC.



Graph: 4

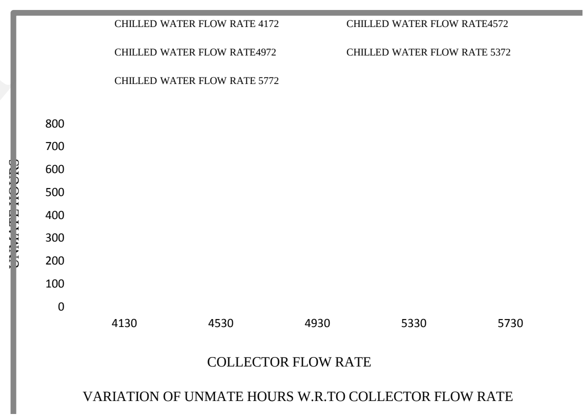


Graph: 5



Graph: 6

Graph 7 shows the the variation of unmet hours with respect to collector flow rate for the various chilled water flow rate to cooling coil and it is clear that 5372 Kg/Hr is the optimum flow rate to get the maximum cooling or minimum unmate hours.



Graph: 7

VII. CONCLUSION

The maximum number of unmet hours (number of hours of any zone outside of throttling range) for the baseline and proposed design must not exceed 300 hours for either case. (Energy conservation building directives for rajasthan-2011and ASHRE fundamental-2009). The above results depicts that unmet hours of all configurations are not satisfied the ECBC's and ASHRAE's mandatory requirements. Thus auxiliary heating is provided to all the configurations, start with 6 kW heating element and increasing to get unmet hours below 300 hours. The maximum supply fan flow rate is also increased from 1800 kg/hr to 2250 kg/hr.

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