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ANALYSIS OF SOLAR TYPE AIR CONDITIONING SYSTEM FOR COMMERCIAL BUILDING

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Abstract: *A new system of solar air-conditioning, which adds the heat pump into the original solar air-conditioning, is proposed in order to improve the solar energy application grade. The new type of solar air-conditioning system will be analyzed and compared with the original system. Solar cooling is a good example of addressing climate changes. In this paper, we provide overviews for working principles of solar thermally operated cooling technologies and reviews for advancements of such technologies from the most recent publications. Researches of solar absorption cycles investigated new refrigerant absorbent pairs and various system configurations that could lead to increasing solar fraction and extending the cycle operation. Researches of solar adsorption cycles focused on the development and testing of various adsorbent refrigerant pairs, improving cycle components, and increasing the system efficiency. For the ejector cycles, many studies focused on using computer models and experimental works to investigate the performance of the ejector and find the key parameters affecting its operation.*

I- INTRODUCTION

The energy needed to process and circulate air in buildings and rooms to control humidity, temperature, and cleanliness has increased significantly during the last decade especially in developing countries. This energy demand has been caused by the increment of thermal loads to fulfill occupant comfort demands, climate changes, and architectural trends. The growth of electricity demand has increased especially at peak loads hours due to high use of driven vapor compression refrigeration machines for air conditioning. In addition, the consumption of fossil fuels and the emissions of greenhouse gases associated with electricity generation lead to considerable environmental consequences and monetary costs.

Conventional energy resources will not be enough to meet the continuously increasing demand in the future. In this case, an alternative solution for this increasing demand of electrical power is solar radiation, available in most areas and representing an excellent supply of thermal energy from renewable energy resource.

One of the most common solar air conditioning alternatives is a solar powered absorption system. The solar absorption system is similar in certain aspect to the conventional vapor compression air conditioning system in that the electrical compressor; is replaced with a solar-powered generator and absorber. Figure shows a commercial flat-plate solar-powered single-effect absorption cooling system.

Fig: Flat-plate solar-powered single-effect absorption cooling system.

The most standard pairs of chemical fluids used include lithium bromide-water solution (LiBr-H2O), where water vapor is the refrigerant and lithium bromide is the absorbent, and ammonia-water solution (NH3-H2O) with ammonia as the refrigerant and water the absorbent. The implementation of computer modeling of thermal systems offer a series of advantages by eliminating the cost of building prototypes, the optimization of the system components, estimation of thermal energy loads delivered or received from or into the system, and prediction of variations of the system parameters (e.g. temperature, pressure, mass flow rate).

Principle of operation

The working fluid in an absorption refrigeration system is a binary solution consisting of refrigerant and absorbent. In Fig. 1(a), two evacuated vessels are connected to each other. The left vessel contains liquid refrigerant while the right vessel contains a binary solution of absorbent/refrigerant. The solution in the right vessel will absorb refrigerant vapor from the left vessel causing pressure to reduce. While the refrigerant vapor is being absorbed, the temperature of the remaining refrigerant will reduce as a result of its vaporization. This causes a refrigeration effect to occur inside the left vessel. At the same time, solution inside the right vessel becomes more dilute because of the higher content of refrigerant absorbed. This is called the "absorption process". Normally, the absorption process is an exothermic process; therefore, it must reject heat out to the surrounding in order to maintain its absorption capability.

Whenever the solution cannot continue with the absorption process because of saturation of the refrigerant, the refrigerant must be separated out from the diluted solution. Heat is normally the key for this separation process. It is applied to the right vessel in order to dry the refrigerant from the solution as shown in Fig. The refrigerant vapor will be condensed by transferring heat to the surroundings.

With these processes, the refrigeration effect can be produced by using heat energy. However, the cooling effect cannot be produced continuously as the process cannot be done simultaneously. Therefore, an absorption refrigeration cycle is a combination of these two processes as shown in Fig. 2. As the separation process occurs at a higher pressure than the absorption process, a circulation pump is required to circulate the solution. Coefficient of Performance of an absorption refrigeration system is obtained from;

$$COP = \frac{\text{cooling capacity obtained at evaporator}}{\text{heat input for the generator + work input for the pump}}$$

Cooling capacity obtained at evaporator heat input for the generator + work input for the pump. The work input for the pump is negligible relative to the heat input at the generator; therefore, the pump work is often neglected for the purposes of analysis.

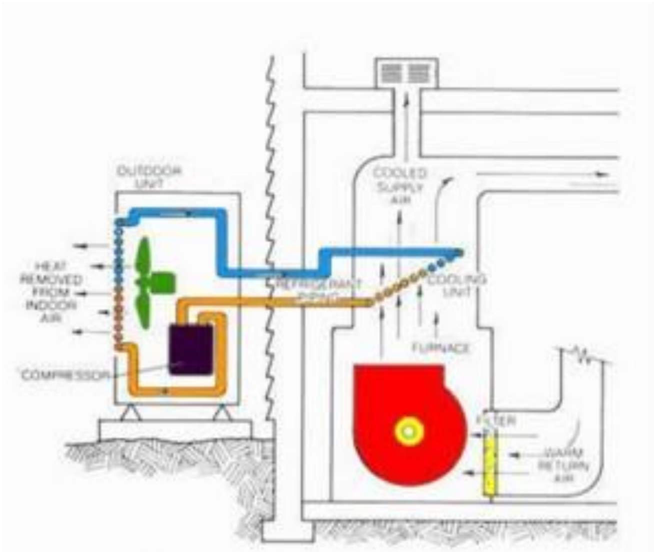
II - AIR CONDITIONING SYSTEMS

Types of Air Conditioning Systems:

There are various types of air conditioners like window air conditioner, split air conditioner, packaged air conditioner and central air conditioning system. This series of articles describes all types of air conditioners.

1 Window Air Conditioning System
2. Split Air Conditioner System
3. Central Air Conditioning Plant
4. Packaged Air Conditioners

A. The Working Principle of Central Air Conditioner



Central Air-Conditioning & Heating System

Detailed Working of Central AC System:

Central air conditioning units are usually matched with a gas or oil furnace to provide heat through the same set of ducts. There are also central HVAC units called heat pumps that combine both the heating and cooling functions. If you heat your home with electricity, a heat pump system is the most efficient unit to use in moderate climates. It can provide up to three times more heating than the equivalent amount of electrical energy it consumes. A heat pump can trim the amount of electricity you use for heating as much as 30 percent to 40 percent.

Even though air conditioners and heat pumps require the use of some different components, they both operate on the same basic principles.

Working of Central A/C

Heat pumps and most central air conditioners are called "split systems" because there is an outdoor unit (called a condenser) and an indoor unit (an evaporator coil). The job of the heat pump or air conditioner is to transport heat from one of these units to the other. In the summer, for example, the system extracts heat from indoor air and transfers it outside, leaving cooled indoor air to be recalculated through your ducts by a fan.

A substance called a refrigerant carries the heat from one area to another. Basically, here's how it works:

The compressor in your outdoor unit will change the gaseous refrigerant into a high temperature, high-pressure gas. As that gas flows through the outdoor coil, it loses heat. That makes the refrigerant condense into a high temperature, high pressure liquid that flows through copper tubing into the evaporator coil located in your fan coil unit or attached to your furnace.

At that point, the liquid refrigerant is allowed to expand, turning the liquid refrigerant into a low temperature, low pressure gas. The gas then absorbs heat from the air circulating in your home's ductwork, leaving it full of cooler air to be distributed throughout the house. Meanwhile, the low temperature, low pressure refrigerant gas returns to the compressor to begin the cycle all over again.

While your air conditioner or heat pump cools the air, it also dehumidifies it. That's because warm air passing over the indoor evaporator coil cannot hold as much moisture as it carried at a higher temperature, before it was cooled. The extra moisture condenses on the outside of the coils and is carried away through a drain. The process is similar to what happens on a hot, humid day, when condensed moisture beads up on the outside of a glass of cold lemonade.

III - LITERATURE SURVEY

With the rapid development of science and technology, human is faced with the growing shortage of conventional resources and the threat of environmental pollution. Many countries began to develop and make use of low-grade energy

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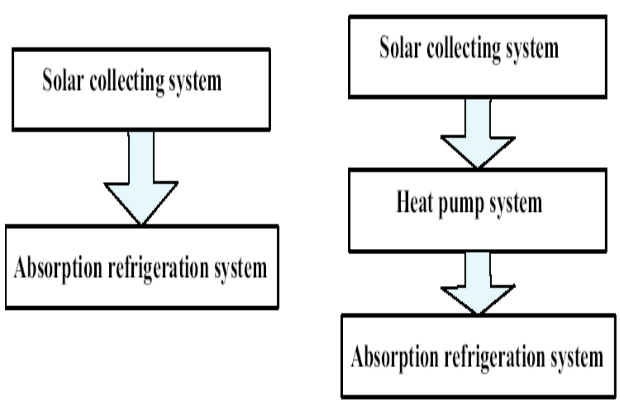
sources such as solar, geothermal, industrial waste heat, etc. These sources become the object of concern because they are clean and green renewable energy, and have large reserves. The concept of solar cooling is appealing because the refrigerating demand and the supply of solar radiation are almost in phase with each other. But the intensity of solar radiation changes periodically and even becomes none at night, so how to get the solar refrigeration cycles to be able to steadily run is of great importance. Based on the above issues, scholars do lots of researches in the following three aspects:

Firstly, a new structure of system which uses low intensity solar energy to reduce the working temperature is developed. Ahachad proposed a two-stage solar machine which can be operated at lower hot source temperatures and can be obtained either from .at plate collectors or from thermal ef.uents. Eicker analyzed the performance and economics of solar thermal absorption chiller systems. Venegas brought forward a new triple-stage absorption cycles for refrigeration which ware adequate for low-temperature heat below 90 .C. Wang demonstrated that a new improved cycle was able to run steadily when driven by low-grade thermal sources as low as 65 .C, and to produce deep refrigeration temperature as low as -40 .C for a three-staged cycle.



Original solar system

New type of solar system

Schematic diagram of the difference between the original system and the new system

Secondly, an energy storage device or auxiliary heat source which suits low or none solar intensity conditions is equipped into the original system. Dennis proposed a solution which installed a cold storage indoors for the solar cooling system which cannot provide nocturnal refrigeration. In order to relieve the impact of short-period cloudy weather, Henrik thought that it might be useful to store part of the regenerated solution and the refrigerant separately. Xu presented a new solar powered absorption refrigeration (SPAR) system with advanced energy storage technology. The energy collected from the solar radiation was first transformed into the chemical potential of the working fluid and stored in the system. The proposed system can solve the problem of the unconformity between solar radiation and cooling demand. Liu presented an innovative concept for a long-term energy storage system. The solar energy is absorbed and stored in the summer through the analytic function, and release heat in winter through the adsorption.

Thirdly, the parameters which in.uence system performance are explored and adjusted in order to ensure the working of cooling system in the best conditions. Tsoutsos studied the performance and economic evaluation of a solar cooling system by using the transient simulation program. Yin experimented a mini-type solar absorption cooling system under different cooling modes. Marc also experimented a solar cooling absorption system operating without any backup system under tropical climate.

Alkhamis researched the cooling system which was influenced by collector area and storage volume. The average yearly performance of the simulated system was shown to be more sensitive to the collector area than the storage volume. Rodriguez-Hidalgo analyzed instantaneous

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performance of solar collector. Sumathy presented that the adsorbent mass and the solar collector area had significant effect on the system performance as well as on the system size. Kaushik's study found the coefficients of performance were reduced at high generator temperatures.

However, an increase of condenser temperature of operation improved the performance of the systems at high generator temperature. Nidal did a lot of research on activated carbon – methanol adsorption refrigeration. The results of model test and data analysis showed that the increase of adsorption mass quantity will lead to the increase of coefficient of performance (COP), the increase of tank capacity cause the increase of COP, the increase of collection hot area result in the increase the COP.

IV - HAP CALCULATION

HAP (Hourly analysis program) soft ware is used to calculate heat load calculation of the system. By this system total tonnage of the machine that to be installed is known, by giving the inputs such as exposures present in the space, occupancy density, lighting and electrical load of the space.

Procedure for calculation is as follows:

Step1: A weather property of the location where the building is located is entered.

Step2: Schedules such as lighting, people, electrical should be prepared in project libraries.

Step3: Exposures and u values are given for wall, window and roof in project libraries.

Step4: In spaces according to the orientation of the individual room exposure of walls, windows and roofs are entered.

Step5: In system, type of machine to be installed is given in which spaces are added to each machine depending upon the requirement

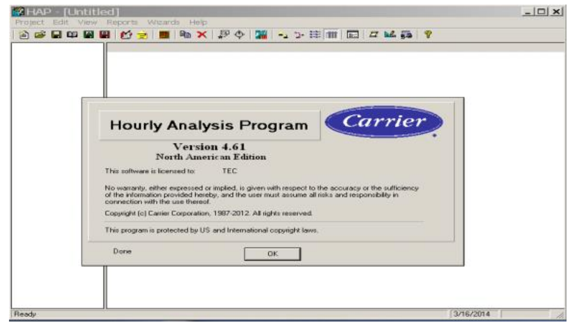

Fig: Hap Software

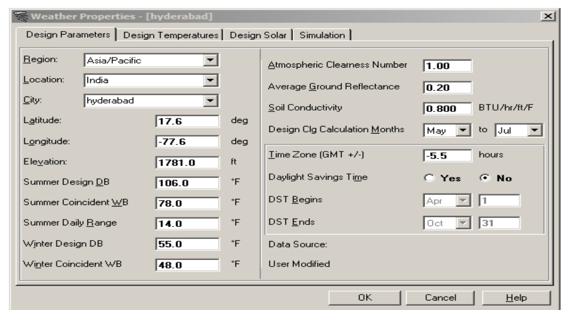

Fig: Weather condition entries [HAP]

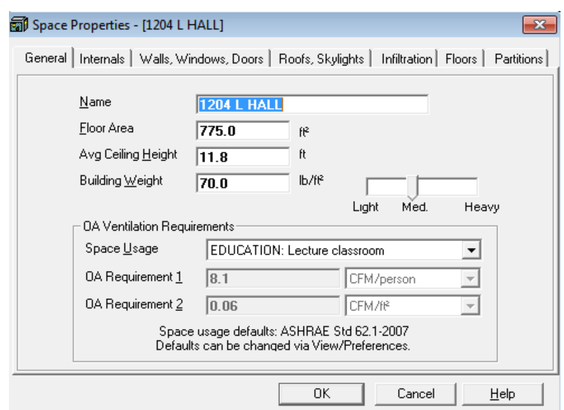

Fig: Dialog Box for Space Properties-General

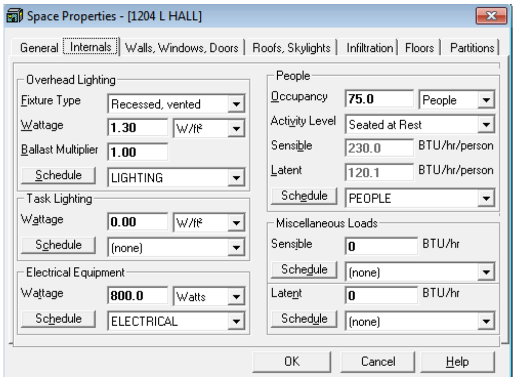

Fig: Dialog Box for Space Properties-Internals

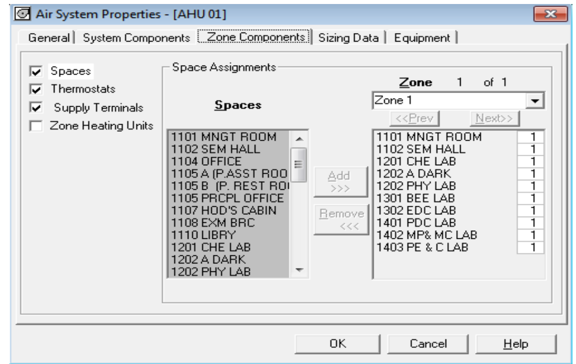

Fig: Dialog box for air system properties

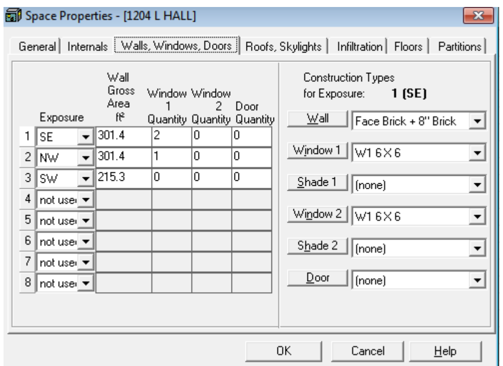

Fig: Dialog Box for Space Properties-Walls, windows and doors

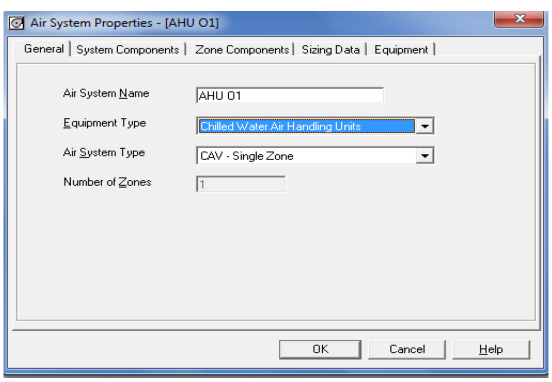

Fig: Dialog box for air system properties

(HYDERABAD)

Design Weather Parameters & MSHGs

Design Parameters:

City Name	**HYDERABAD**	
Location	**India**	
Latitude	**17.0**	Deg.
Longitude	**-77.6**	Deg.
Elevation	**1781.0**	ft
Summer Design Dry-Bulb	**106.0**	°F
Summer Coincident Wet-Bulb	**78.0**	°F
Summer Daily Range	**14.0**	°F
Winter Design Dry-Bulb	**55.0**	°F
Winter Design Wet-Bulb	**48.0**	°F
Atmospheric Clearness Number	**1.00**	
Average Ground Reflectance	**0.20**	
Soil Conductivity	**0.800**	BTU/(hr-ft-°F)
Local Time Zone (GMT +/- N hours)	**-5.5**	hours
Consider Daylight Savings Time	**Yes**	
Daylight Savings Begins	**April, 1**	
Daylight Savings Ends	**October, 31**	
Simulation Weather Data	**noneN/A**	
Current Data is	**User Modified**	
Design Cooling Months	**May to July**	

Fig: Weather Condition

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Air System Sizing Summary for 1F-AHU-01

Project Name: (HYDERABAD)
Prepared by:

Air System Information

Air System Name	Conference Hall	Number of zones	1	
Equipment Class	AHU	Floor Area	426	ft²
Air System Type	SZCAV	Location	HYDERABAD, India	

Sizing Calculation Information

Zone and Space Sizing Method:

Zone CFM	Sum of space airflow rates	Calculation Months	May to Jul
Space CFM	Individual peak space loads	Sizing Data	Calculated

Central Cooling Coil Sizing Data

Total coil load	4.3 Tons	Load occurs at	Jun 1700	
Total coil load	270.5MBH	OA DB / WB	105.6 / 77.9	°F
Sensible coil load	270.5MBH	Entering DB / WB	82.9 / 70.4	°F
Coil CFM at Jun 1700	1350 CFM	Leaving DB / WB	55.6 / 54.7	°F
Max block CFM	1350 CFM	Coil ADP	52.6	°F
Sum of peak zone CFM	1350 CFM	Bypass Factor	0.100	
Sensible heat ratio	0.571	Resulting RH	67	%
ft²/Ton	77.6	Design supply temp.	58.0	°F
BTU/(hr-ft²)	154.7	Zone T-stat Check	1 of 1	OK
Water flow @ 10.0 °F rise	83.19 gpm	Max zone temperature deviation	0.0	°F

Central Heating Coil Sizing Data

Max coil load	26.2MBH	Load occurs at	Des Htg	
Coil CFM at Des Htg	7500 CFM	BTU/(hr-ft²)	9.7	
Max coil CFM	7500 CFM	Ent. DB / Lvg DB	66.8 / 69.8	°F
Water flow @ 20.0 °F drop				

Supply Fan Sizing Data

Actual max CFM	1738 CFM	Fan motor BHP	4.71	BHP
Standard CFM	1738 CFM	Fan motor kW	3.74	kW
Actual max CFM/ft²	3.20CFM/ft²	Fan static	2.00	in wg

Outdoor Ventilation Air Data

Design airflow CFM	28 C	CFM/person	5.86	CFM/person
CFM/ft²	0.71 C			

Fig: Air System Sizing Summary

V - CONCLUSION

In conclusion, the use of HPS can lift the low-grade collection energy to a high-grade which is needed to supply ARS. Especially, the evaporation temperature of the heat pump system can be maintained the required value by adjusting the rotational speed of the pump and the level height of water tank.

In order to quantify the difference between the new type solar system and the old one, based on day's solar radiation intensity values in Nanjing, respectively select 0.2 kW/m2 and 0.8 kW/m2 as the calculation value of low solar radiation intensity and high solar radiation intensity. The results show that:

(1) When the sun radiation intensity is high, the cooling capacity of the new system is 1.7 times the original system under the calculation conditions chosen in this paper. When the sun radiation intensity is low, although the cooling capacity of the new system is decreased by 70% compared to high radiation intensity conditions, it can also provide cooling. However, the original system cannot provide refrigeration.

(2) In a certain solar radiation intensity, new type solar air-conditioning system can reduce the requirement of a high efficiency SCS comparing with the original system. Additionally, for the new type of solar system, it can operate stably by adjusting the water mass flow rate of SCS under different solar radiation intensities.

(3) For the heat pump system (HPS) of the new type solar system, under the same rage of evaporation temperature and condensation temperature, the system which uses R600a as refrigerant in heat pump system (HPS) has higher COP. And at the same cooling capacity of ABS, R600a HPS has less power consumption than R134a HPS.

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