International Journal Of Advance Research, Ideas And Innovations In Technology

ISSN: 2454-132X
Impact Factor: 6.078
(Volume 7, Issue 4 - V7I4-1375)
Available online at: https://www.ijariit.com

Solar Energy for Refrigeration and Air Conditioning

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ABSTRACT

In today's world, the demand for comfort has been growing at an exponential rate. The utilization of air-conditioning and refrigeration systems has increased, which results in higher costs and consumption of energy. It is one of the main constituents of Global Warming. For example, Indian market of air conditioners was of worth $4.3 billion in 2017and will be of $11 billion by 2023 with a mean growth of 17% per annum.[2] Consequently, India produced roughly 2.5 billion tons CO2 within the year 2018. As a result, a substitute for conventional method of air conditioning is being searched. Use of solar energy in air conditioning and refrigeration can be a substitute. It helps in reduction of the consumption, the demand, and therefore costs of energy, without decreasing the desired comfort. These systems help in air conditioning and may even be used for refrigeration purposes. The can easily be used in commercial and residential apartments, colleges, hospitals, hotels etc. In this paper we will discuss the functioning of these systems and future scope of solar power in air conditioning and refrigeration.

Keywords: *Air-conditioning, Refrigeration CO_2 emissions, solar power*

1. SOLAR POWERED AIR REFRIGRATION SYSTEM

1.1 Introduction

- Energy is the primary and universal measure of all kinds of labor done by human being and nature.
- The energy demand is increasing day by day because of increasing population, increasing industrialization and increasing transportation etc.
- Day by day energy demand is growing exponentially. Supply is depleting, leading in inflation and energy shortage.. This is often called the energy crisis.
- Non conventional sources of energy are required to be developed .

1.2 Components

1.2.1 Solar Equipment

- **Solar Panel:** Solar panel refers either to a photovoltaic module, a solar thermal energy panel, or a group of solar photovoltaic (PV) modules electrically connected and mounted on a supporting structure.
- **Battery:** Battery stores the electrical power in the form of a chemical reaction. Without storage you would only have power when the sun is shining or the generator is running. We need battery of 48V.
- **Inverter:** The power inverter is the heart of the system. It makes 220 volts AC from the 12 volts DC stored in the batteries. It also can also charge the batteries if connected to a generator or the AC line.
- **Charge Controller:** It helps in preventing overcharging of battery. Prevents damage to the battery and increases its battery. It also helps in preventing reverse current. It displays battery status and flow of power.

1.2.2 Compressor

The compressor is controlled by the thermostat that's one among the air conditioning systems. The compressor works because the pump that pushes the refrigerant to flow through the system. Its job is to attract a low-pressure, low-temperature refrigerant gas during a gaseous state and, by compressing the gas, surge the pressure and temperature of the gas refrigerant. This high-pressure gas moves towards the condenser coil.

1.2.3 Condenser

In a cooling cycle of a cooling system, heat is absorbed by the vapor refrigerant within the evaporator followed by the compression of the refrigerant by the compressor. The large pressure and high temperature state of the vapor refrigerant is then converted to liquid at the cond. It is designed in such a way that it can condense effectively the compressed refrigerant vapor.

The condenser coil may be a series of piping alongside a lover that pulls air from outside. As the refrigerant goes through the condenser coil and therefore the cold air passes across the coil, the air absorbs heat from the refrigerant that causes the refrigerant and converts gas to a liquid state. The high-pressure liquid then reaches the expansion valve and does the remainder.

The evaporator coil may be a series of piping attached to an air handler that blows indoor air across it, causing the coil to soak heat from the surface air. The cooled air is then flooded to the whole house through ducts. The liquid refrigerant then moves back to the compressor, where the same cycle is started again. Evaporators coil primary function is to extract heat from the atmosphere and adding the refrigerant gas to it.

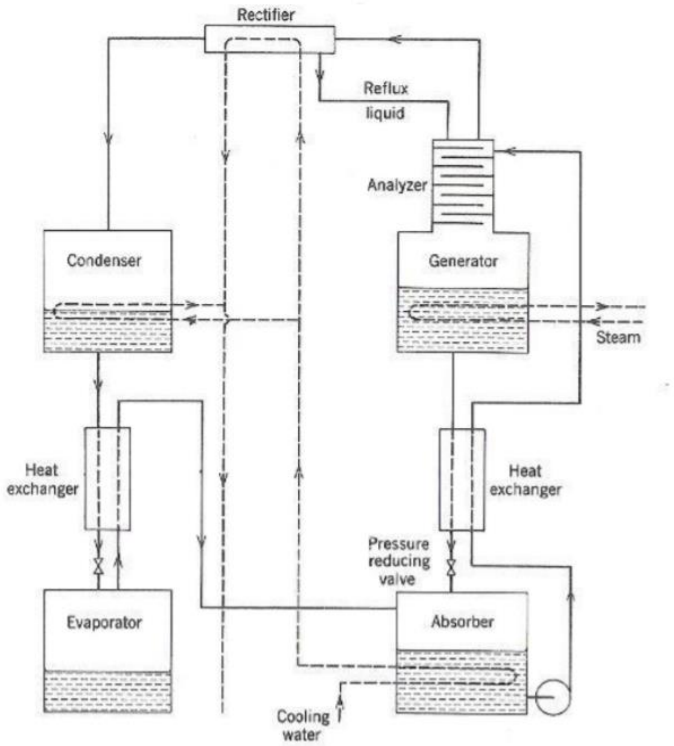
1.2.4 Expansion Valve

It controls the quantity of refrigerant flow into the evaporator. It causes a sudden pressure drop (Isenthalpic) of the working fluid in the system. It causes sudden drop in temperature. The type of expansion valves used in solar powered air conditioners are capillary type expansion valve.

1.2.5 Evaporator

It is used for absorption of heat from surroundings. The evaporator coil is full of evaporated refrigerant that the compressor pumps to the metering device as liquid then into the evaporator. The air that is pushed through the coil from the blower fan will move over the coil where the refrigerant in the evaporator will absorb the heat.

2. USE OF SOLAR POWER IN AMMONIA ABSORPTION REFRIGRATION SYSTEM



(a) Evaporator: The evaporator is the part where the refrigerant pure ammonia (NH3) in liquid state, produces the refrigerant effect. It sucks out all the heat from the substance to be cooled and evaporates. From here, the ammonia moves ahead to the absorber in the gaseous form. [1]

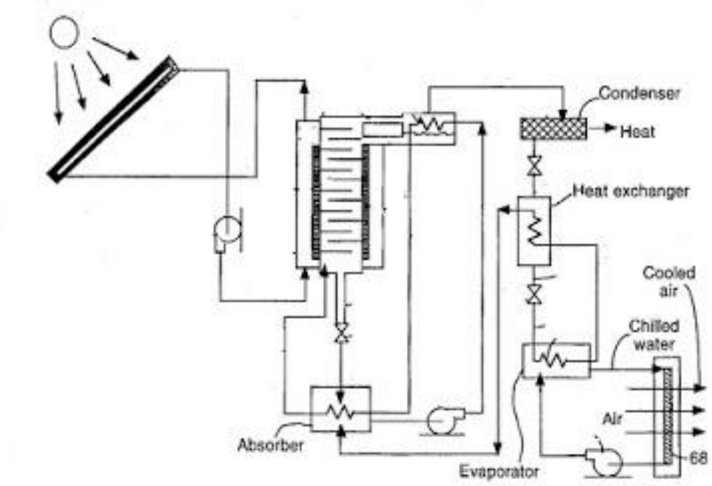
(b) Absorber: Absorber already contains the weak solution of Ammonia-Water. The water which is used as the absorbent in the solution is unsaturated. It has the capacity to absorb more ammonia gas. The ammonia entering absorber from evaporator gets absorbed by weak ammonia-water solution and forms a strong one. The ammonia absorbing capacity gets reduced due to the heat produced, therefore the absorber is cooled by the cooling water.

(c) Pump: The strong solution of ammonia and water from the absorber is pumped by the pump to the generator.

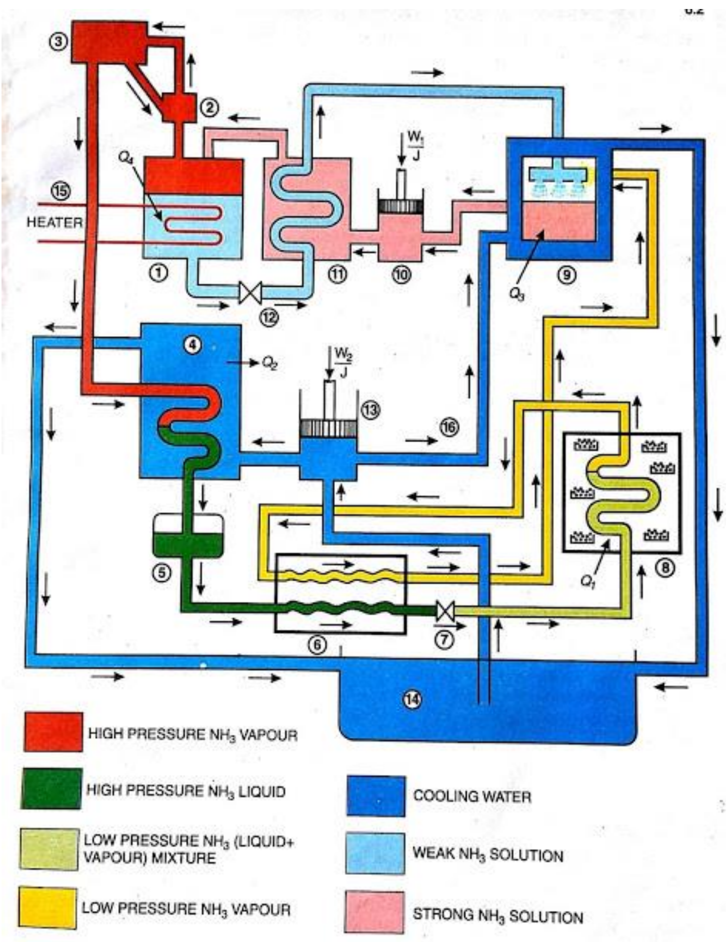
(d) Generator: After reaching the generator, the strong ammonia-water solution is heated with the help of some external source such as heat or solar energy. Other sources like natural gas, electric heater, and waste exhaust heat can also be used. As the refrigerant ammonia is heated it gets evaporated and leaves the generator. It is important to pass this refrigerant from analyzer, because water has higher affinity for ammonia and its vaporization point is low, hence some water particles also get carried away.

(e) Analyzer: The ammonia refrigerant leaving the generator carries appreciable amount of water vapor reducing the refrigerating capacity of the system. The water vapor from ammonia refrigerant is removed by analyzer and the rectifier. Analyzer is made up of number of plates positioned horizontally. As ammonia refrigerant along with the water vapor particles reaches the analyzer, the solution is cooled down. Water having higher saturation point condenses and drips to generator. The ammonia refrigerant in the gaseous state continues to move up.

(f) **Condenser and expansion valve:** As the pure ammonia refrigerant in gas phase reaches the condenser, it is cooled down. The refrigerant ammonia then gets converted into the liquid form and it then passes through the expansion valve where its temperature and pressure falls down suddenly. At last ammonia refrigerant produces the cooling effect. This cycle keeps on repeating continuously. Meanwhile, when ammonia gets vaporized in the generator, weak solution of ammonia and water is left in it. This solution is expanded in the expansion valve and passed back to the absorber and its cycle repeats.



The heat required for the generator to separate the ammonia from weak solution is achieved by solar radiation in our system the solar radiation is concentration by reflector or solar concentrator. First the concentrated heat from reflector is used to heat the water and so that water is converted into steam that steam is use to heat solution steam which is coming out from generator is re circulated and regenerated to required state.



Practical Ammonia Water Absorption Refrigeration System

The basic components of practical NH3 absorption system are listed below.

(a) Generator
(b) Analyzer
(c) Rectifier
(d) Condenser
(e) Receiver
(f) Heat exchanger1

(g) Expansion valve
(h) Evaporator
(i) Water jacked absorber
(j) Pump p1
(k) Heat exchanger he2
(l) Expansion valve ev2
(m) Pump p2
(n) Pond containing cooling water
(o) Heating coil

3. PROGRESS OF INTERMITTENT SOLAR REFRIGRATION SYSTEM

- Kirpichev and Baum in 1954 reported a solar refrigerator capable producing of 250kg of ice per day. Steam is employed as working fluid which produced by a cylindrical parabolic concentrators.[3]
- Trombe and Foex in 1957 built a intermittent solar refrigerator of production capacity 6 kg per ice per day performing on vapor absorption principle and ammonia- water combination used as working fluid.[4]
- Willam et al (1957) tried different refrigerant-absorbent combination like methonol-silicagel, accetone-silicagel, ammonia-water etc, for a small food cooler working on intermittent cycle.
- Giri and Barve (1978) built a solar absorption system of one ton capacity with 18 flat plate collectors each having 2m2 area producing a cooling rate of 2769 Kcal/h with solar energy input 4390 Kcal/h.[5]
- Ramesh chandra et al (1978) built a solar refrigerator, NH_3 -NaSCN as working fluid which is operated 0°C evaporator temperature and 104°C generator temperature.

4. COST EFFECTIVENESS OF SOLAR REFRIGRATION VS. CONVENTIONAL REFRIGRATION

DATA ANALYSIS

Solar refrigerator versus conventional refrigerator (Payback Analysis)

From the table shown below, the payback time has been calculated by considering the initial system cost.

REVENUES AND EXPENSES							
	2011	2012	2013	2014	2015	2016	2017
	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Initial System Cost for Solar Refrigerator	Rs.30,950	Running Cost					
Running cost for Conventional Refrigerator (Rs.)		4,818	5,083	5,363	5,658	5,970	6,299
Cumulative Running Cost (Rs.)		4,818	9,901	15,264	20,922	26,892	33,191
Payback Cost (Rs.)		-26,132	-21,049	-15,686	-10,028	-4,058	2241

Table : Calculation Of Payback Cost For Solar Refrigeration System

[6]

Cost comparison of solar and electrical refrigerator

• The total cost of a selected refrigerator for 10 years is = Rs.8390 + Rs. 62,052 = Rs.70,442 /-
• For solar based refrigeration system, the total initial cost is = Rs 39,340
• The saving of cost in 10 years is with a difference of = 70,442 − 39,340 = Rs. 31,102.
• Saving per year is = **Rs 31102.00**

5. REFERENCES

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