SOLAR THERMAL ABSORPTION AIR CONDITIONER STAAC

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ABSTRACT

The project consists of an Electrolux refrigeration system using solar energy as input. This system was actually invented by two Swedish engineers, Von Platen and Carl Munters. The idea was first developed by the 'Electrolux Company, of Luton, England, hence the name 'Electrolux refrigeration system'. The modified Electrolux unit is that it uses three gases to accomplish its cooling effect namely water (refrigerant) Lithium Bromide (absorbent) and hydrogen. Water is used as the refrigerant as it is easily available, environmentally friendly and can produce a better cooling effect. Hydrogen is used to reduce the partial pressure of water vapour in the evaporator chamber so that more water evaporates yielding more cooling effect. Heat input is required at the generator where Lithium Bromide-water solution is heated to get water vapors. In this paper, an experimental setup for Electrolux air conditioning unit is made using solar energy to supply input heat. A parabolic point focusing dish is used as the solar collector. A parallel flow type heat exchanger is set up to act as generator pipes. Solar energy is concentrated to these pipes by the solar collector, heating the Lithium Bromide-water solution. The rest of the system is unaltered.

Keywords: Solar Energy, Electrolux VapourAbsorption Cycle, LiBr-Water Solution.

I. INTRODUCTION

If the solar energy possesses the advantage to be "clean", free and renewable, this last is probably, considered like an adapted potential solution, that answers in even time at an economic preoccupation and ecological problems. Among the main done currently research is the use of this free source to make operate system of refrigeration. Since among the domestic appliances used today, refrigerators consume a considerable amount of energy, using solar energy to run refrigerator is of great practical relevance nowadays.

The diffusion absorption refrigerator cycle invented in the 1920s is based on ammonia (refrigerant) and water (absorbent) as the working fluids together with hydrogen as an auxiliary inert gas. Since there are no moving parts in the unit, the diffusion absorption refrigerator system is both quiet and reliable. The system is, therefore, often used in hotel rooms and offices. The absorption diffusion refrigerating machine is designed according to the operation principle of the refrigerating machine mono pressure invented by PLATERN and MUNTER. This machine uses three operation fluids, water (absorbent), the ammonia (refrigerant) and hydrogen as an inert gas used in order to maintain the total pressure constant

1.1 Background

A study includes an experimental investigation into the use of vapor absorption refrigeration (VAR) systems in road transport vehicles using the waste heat in the exhaust gases of the main propulsion unit as the energy source. This would provide an alternative to the conventional vapor compression refrigeration system and its associated internal combustion engine. The performance of a VAR system fired by natural gas is compared with that of the same system driven by engine exhaust gases. This showed that the exhaust-gas-driven system produced the same performance characteristics as the gas-fired system. It also suggested that, with careful design, inserting the VAR system generator into the main engine exhaust system need not impair the performance of the vehicle propulsion unit. A comparison of the capital and running costs of the conventional and proposed alternative system is made.

Hosni I. and Abu-Mulaweh [3], a prototype of a solar water heating system was constructed and tested. The solar collector rotated as the sun position/angle was changing, indicating the functionality of the control system that was design to achieve this task. Experimental measurements indicate that the water in the tank was heated by the solar energy being absorbed by the solar collector. Moreover, the water temperature measurements at different heights in the storage tank show the thermo-siphon effect. Solar water heating utilizing thermo-siphon is attractive, because it eliminates the need for a circulating pump. Results indicate that the design of the thermo-siphon solar water heating system was a success. Furthermore, the experimental apparatus described in this article is a valuable addition to the undergraduate mechanical engineering laboratory. The experimental apparatus is portable, and it can be used as an instructional experimental apparatus for demonstrating basic heat transfer principles and thermo-siphon concept.

V Mittal et.al [6], in their work they found out solar absorption air-conditioning has the advantage of both the supply of sunshine and the need for refrigeration to reach maximum levels in the same season. Of the two main technologies of solar cooling systems namely, solar thermal technology and solar cooling technology, the emphasis in this paper is placed on solar cooling technology. Some of the findings of their work are as follows: Among the major working pairs available, LiBr-H_2O is considered to be better suited for solar absorption air-conditioning applications. Generator inlet temperature of the chiller is the most important parameter in the design and fabrication of a solar powered air-conditioning system. A Single effect system with refrigerant storage has the advantage of accumulating refrigerant during the hours of high solar insolation but the double effect convertible system has a higher overall COP.

M. Kaplan, Solar thermal technology is concerned principally with the utilization of solar energy by converting it to heat. In the concentrating type of solar collector, solar energy is collected and concentrated so that higher temperatures can be obtained; the limit is the surface temperature of the sun. Similarly, overall efficiency of energy collection, concentration, and retention, as it relates to energy cost, imposes a practical limit on temperature capability. The cusp collector whose surface geometry is the locus of the position of the end of a string as it is unwrapped from a pipe can provide a modest concentration suitable to boil water.

Many research papers have been published on ammonia-water vapour absorption systems, but an attempt has not been made to analyze the LiBr-Water vapour absorption systems using solar thermal energy, to the best knowledge of the investigator. Therefore, it is imperative to investigate the performance analysis of the LiBr-Water vapour absorption systems using solar thermal energy.

II. ELECTROLUX VAPOUR ABSORPTION SYSTEM USING SOLAR THERMAL POWER

2.1 History

In 1922, two young engineers, Baltzar von Platen and Carl Munters from the Royal Institute of Technology in Stockholm, submitted a degree project that gained them much attention. It was a refrigeration machine that employed a simple application of the absorption process to transform heat to cold. The heat source that initiated the process could be fueled by electricity, gas or kerosene, making the system extremely flexible. The two inventors needed money to develop and market their product, however. By 1923, they had come as far as establishing two companies, AB Arctic and Platen-Munters Refrigeration System. Refrigerator production got under way now, albeit on a small scale, at the new Arctic factory in Motala. The absorption refrigeration machine was far from fully developed when Wenner-Gren began to take an interest in it. It was, then, a bold move when he made an offer for the two companies, which meant Electrolux's future would depend on the success of the refrigerator. In 1925, Electrolux introduced its first refrigerators on the market. Intense efforts to develop refrigeration technology were under way at a refrigeration lab that had been set up in Stockholm. The primary goal was to develop an air-cooled system. Platen-Munters' first appliance was water-cooled and had to be connected to a heat source, a water line and a drain in order to function. It was a fairly impractical solution. This was one of the reasons for bringing physicist John Tandberg to the lab. Tandberg was one of the specialists who played a key role in the development of refrigeration technology at Electrolux, making contributions to improving the control of corrosion and rust and much more.

2.2 Modified Domestic Electrolux Vapour Absorption Cycle

Fig.1. shows a schematic diagram of Modified Electrolux Absorption unit. The continuous absorption type of cooling unit is operated by the application of a limited amount of heat furnished by gas, electricity or kerosene. No moving parts are employed.

The unit consists of four main parts - the boiler or generator, condenser, evaporator and absorber.The unit can be run on electricity. When the unit operates on electricity the heat is supplied by a heating element inserted in the pocket. The unit charge consists of a quantity of Lithium Bromide, water and hydrogen at a sufficient pressure to condense water at the room temperature for which the unit is designed. When heat is supplied to the boiler system, bubbles of water gas are produced which rise and carry with them quantities of weak lithium bromide solution through the siphon pump. This weak solution passes into the tube, while the water vapor passes into the vapor pipe and pass to the condenser. Air circulating over the fins of the condenser removes heat from the water vapor to cause it to condense to liquid water in which state it flows into the evaporator. The evaporator is supplied with hydrogen. The hydrogen passes across the surface of the water and lowers the water vapor pressure sufficiently to allow the liquid water to evaporate.

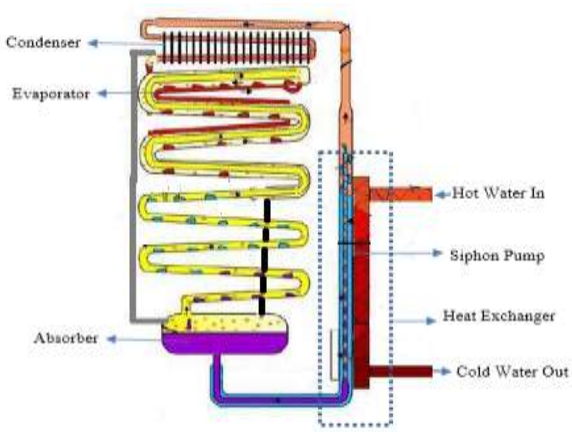

Figure.1. Modified Electrolux Absorption Unit

The evaporation of the water extracts heat from the food storage space, as described above, thereby lowers the temperature inside the refrigerator. The mixture of water and hydrogen vapor passes from the evaporator to the absorber. The weak solution, flowing down through the absorber comes into contact with the mixed water and hydrogen gases which readily absorbs by the lithium bromide solution, leaving the hydrogen free to rise through the absorber coil and to return to the evaporator. The hydrogen thus circulates continuously between the absorber and the evaporator.
The strong lithium bromide solution produced in the absorber flows down to the absorber vessel and then to the boiler system, thus completing the full cycle of operation. The liquid circulation of the unit is purely gravitational. Heat is generated in the absorber by the process of absorption. This heat must be dissipated into the surrounding air. Heat must also be dissipated from the condenser in order to cool the water vapor sufficiently for it to liquefy. Free air circulation is therefore necessary over the absorber and condenser. The whole unit operates by the heat applied to the boiler system and it is of paramount importance that this heat is kept within the necessary limits and is properly applied.
A liquid seal is required at the end of the condenser to prevent the entry of hydrogen gas into the condenser. Commercial Platen-Munters systems are made of all steel with welded joints. Additives are added to minimize corrosion and rust formation and also to improve absorption. Since there are no flared joints and if the quality of the welding is good, then these systems become extremely rugged and reliable. The Platen-Munters systems offer low COPs (of the order of 0.1 to 0.4) due to energy requirement in the bubble pump and also due to losses in the evaporator because of the presence of hydrogen gas. In addition, since the circulation of fluids inside the system is due to buoyancy and gravity, the heat and mass transfer coefficients are relatively small, further reducing the efficiency.

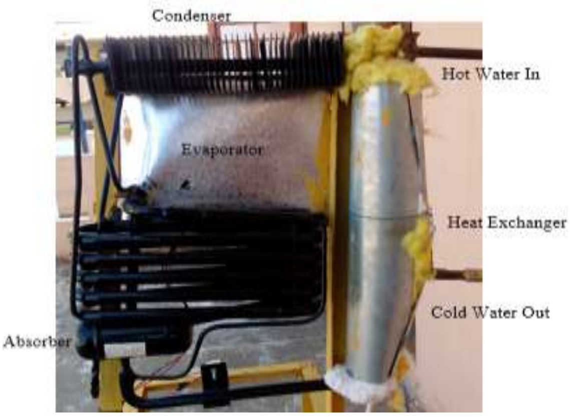

Figure.2 Solar Thermal Electrolux VapourAbsorption System

III.DESIGN AND FABRICATION OF THE SYSTEM

3.1 Design of Parabolic Dish Collector Systems

A parabolic dish collector is similar in appearance to a large satellite dish, but has mirror-like reflectors and an absorber at the focal point. It uses a dual axis sun tracker. A parabolic dish system uses a computer to track the sun and concentrate the sun's rays onto a receiver located at the focal point in front of the dish. In some systems, a heat engine, such as a Stirling engine, is linked to the receiver to generate electricity. Parabolic dish systems can reach 200 °C at the receiver, and achieve the highest efficiencies for converting solar energy to electricity in the small-power capacity range.
Here the collector used is parabolic dish type, designed to achieve maximum temperature at the generator,

TG=120°C.

Solar constant (ISC) =1367 W/m^2 and Extraterrestrial radiation (IO) =1413.5 W/m^2 (for March) Geographical location of the place where the solar collector was placed; college compound (Latitude =10.74N, Longitude =76.45E)

Also the month of operation is assumed to be March ($\delta = 0, \omega = 0$). Direct radiation reaching the surface at earth is a function of time of the day, latitude location and declination angle. Z is the zenith angle, is calculated thus,

$\cos z = \sin\gamma \sin\delta + \cos\gamma \cos\delta \cos\omega$

Where, γ is the latitude of location, δ is the declination angle and ω is the hour angle

$\cos z = \sin(10.74)\sin(0) + \cos(10.74)\cos(0)\cos(0)$

$\cos z = 0.9824829373$

$z = 10.24$

Iz =Isc$e^{(-c(\sec z)s)}$=1068.50 W/m^2

The value of radiation on a horizontal surface (Ih) is

Ih = Iz cos z

Iz = 1068.5018×$\cos(10.74)$ =1049.7847 W/m^2

So the available radiation intensity = 1049.78 W/m^2

Assume, 50% efficiency due to: - Variance, Collector efficiency, Manual tracking system. This implies solar radiation intensity at college compound = 524.89 W/m^2. But, practically we get average solar radiation intensity at college compound = 800 W/m^2 (ground)

Now, reflected intensity (Ri) = 0.8×800 =640 W/m^2(Reflectivity of magnesium coated aluminum sheet=0.8)

Then, Heat required at collector receiver

Qi =5 x 4.18 x (120-30)/3600 Qi = 0.523 kW = 523W

Area of parabolic dish (Ad) = 523/640 =0.81m^2 Take depth (h). h=0.3m

Surface area (As) =$\frac{\pi}{6} \times \left[\frac{(a^2 D^2 + 1)^{\frac{3}{2}} - 1}{a^2}\right]$

By trial and error;

r=0.5m, D=1m

Focal length (F) =r^2/4h = 0.5^2/4×0.3 =0.208m

Ideal operating temperature required at generator=100°C-120°C

3.2 Design Considerations of Electrolux VAS

Generator (bubble pump) Length=25cm, Diameter=2cm Condenser

Length=32cm, Diameter=1.4cm Absorber (Vessel)

Length =12.5cm, Diameter=5.8cm Evaporator

Length=30cm, Diameter=1.4cm Plate fin

No. of fins=40, Length=7cm Width=5cm, Thickness=1mm Condenser pressure=10bar Evaporator pressure=1bar Concentration of LiBr solution=55%

Quantity of LiBr- water solution filled=300ml

3.3 Design of Heat Exchanger

Here the design of heat exchanger used is parallel flow tube type. Taking the temperature deference between incoming and outgoing water is 20^0C. Heat transfer at generator happens via forced convection between hot circulating water and outer tube surface of bubble pump.

IV.CONSTRUCTION AND ASSEMBLY OF THE SYSTEM

The parabolic dish collector was fabricated using eight iron bars of 48 cm length, 2.5 cm width and a large chromium plated aluminium sheet. The base was created by welding eight strips of curved steel to a central point at the base. Then a circular rim of steel of required diameter was created and welded each to the base. Two arms were welded to the dish for holding the heat source. Steel was used for the stand and a square base was used as a support. Mild steel sheet of length 70 cm and breadth 19 cm was taken and rolled into a cylinder to form the collector box. Two holes were made at the ends and fitted with a pipe extension for fixing 2.5 cm copper tubes.

On the top on opposite points two small extensions were welded for fitting on the two arms of the dish. The vessel is fixed on the focal point of the parabolic dish. It is supported at the focal point with the help of cast iron bar. The vessel has a tilting mechanism so that vessel always remains straight. A mini domestic unit of Electrolux vapour absorption was used for the experiments. A vapour absorption system which had specifications and size similar to that of the mini fridge was used. Slight modifications were done to the vapour absorption system.

Figure.3. Experimental Setup of VAS Using Solar Thermal Energy

An alternate pipe was provided to carry hot water through the generator from the solar thermal parabolic dish collector. This pipe was made up of copper with 4 cm in diameter and had an inlet for hot water and an outlet at the top for the colder water. This was placed such that it was in contact with the generator to ensure transfer of heat from the pipe to the generator tube.

V. RESULTS AND DISCUSSION

After the total assembly and calculations were complete the setup was tested. The testing was performed from 9:00 am to 4:00 pm and the reading was noted.

Table.1 Variance of Collector Fluid Temperature with Local Time

Sl.No.	*Local Time (in Hrs.)*	*Ambient Temperature (^0C)*	*Collector Fluid Temperature(^0C)*
1	*9:00*	*27.50*	*50.00*
2	*10:00*	*29.80*	*80.00*
3	*11:00*	*32.30*	*100.00*
4	*12:00*	*32.50*	*130.00*
5	*13:00*	*34.50*	*136.00*
6	*14:00*	*35.60*	*135.00*
7	*15:00*	*35.60*	*130.00*
8	*16:00*	*33.00*	*124.00*

Every half an hour the parabolic dish was adjusted manually to track the movement of the sun. From the testing done it was noted that the lowest temperature achieved was 25^{0}C. It was noted that the cabin temperature increased for a certain period and then dropped.

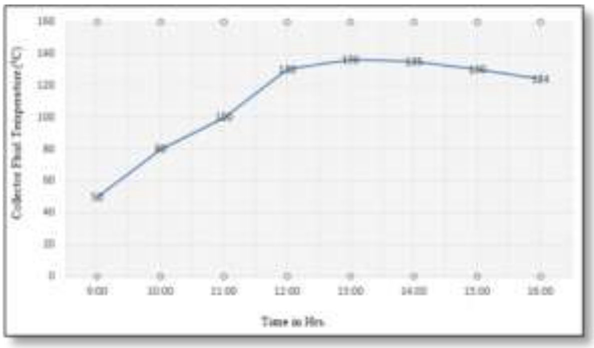

Figure.4 Variance of Collector Fluid Temperaturewith Time

The C.O.P of the system was obtained from the calculations as 0.3131. The result was noted that the collector fluid temperature increased with time but only up to a certain period. It can also be noted that the fluid temperature increases till 14:00 to a temperature of 135^{0}C and then starts dropping.

Now a second set of data is analyzed. Here cabin temperature variance is studied with respect to time. A digital thermometer was used for the purpose. It was noted that the cabin temperature reduces up to 14:00 hrs and then starts to increase. The above pattern can be explained as there is a reduction in the solar radiation as evening approaches.

Table.2Variance of Cabin Temperature with Local Time

Sl.No	*Local Time (in Hrs.)*	*Cabin Temperature (^0C)*
1	*9:00*	*28.5*
2	*10:00*	*27.1*
3	*11:00*	*26*
4	*12:00*	*25*
5	*13:00*	*24.9*
6	*14:00*	*25*
7	*15:00*	*26.2*
8	*16:00*	*27*

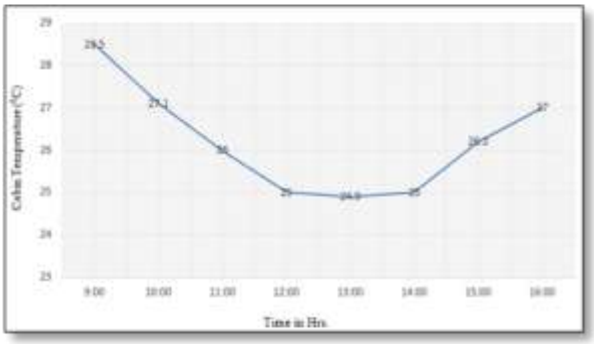

Figure.5 Variance of Cabin Temperature with Time

VI. CONCLUSION & FUTURE SCOPE

In this study the vapour absorption system using solar thermal energy was successfully fabricated. From the study it is observed that the results are up to the expected level and hence the same system can be the best method than the conventional systems.

In future it is decided to compare the performance between conventional systems and vapour absorption system using solar thermal energy.

VII. ACKNOWLEDGMENT

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