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Development and Testing of Vapor Absorption Refrigeration System by Solar Energy

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***Abstract*: This report presents the use of solar energy to produce a refrigeration effect by giving solar heat to the generator of the vapor absorption system. Refrigeration is generally meant to produce a cooling effect by using electrical energy such as a domestic refrigerator and air conditioning system. The access to electricity is difficult in remote areas like rural areas. So, the aim of our project is to produce a cooling effect without electricity and produce a refrigeration effect by solar energy. A conceptual model of the fridge is developed which would be capable of produce cooling easily and it should be economically efficient at free of cost. An attempt is made to heat the refrigerant and aqua solution by use of oil where oil is used as a heat transfer medium to transfer heat from solar radiation to generator.**

***Keywords*: Solar based VARS, various types of fluid for heat transfer.**

1. Introduction

A. Refrigeration

Refrigeration is the process of removing heat from an enclosed space or from a substance and moving it to a place where is unobjectionable. The primary purpose of refrigeration is to lowering the temperature of the enclosed space and maintaining the temperature. The term cooling is referring to any natural or artificial process by which heat is dissipated Method of Refrigeration

Methods of refrigeration can be classified as non-cyclic, cyclic and thermoelectric.

- Non-Cyclic refrigeration
- Cyclic refrigeration

1) Non-Cyclic Refrigeration

In these methods, refrigeration can be accomplished by melting ice or by sublimating dry ice. These methods are used for small scale refrigeration such as in laboratories and workshops.

2) Cyclic Refrigeration

This consists of a refrigeration cycle, where heat is removed from a low-temperature space or source and rejected to a high-temperature sink with the help of external work, and its inverse the thermodynamic power cycle. In this power, cycle heat is supplied from a high-temperature source to the engine part of the heat engine being used to produce work and the rest being rejected to a lower temperature sink. This satisfies the thermodynamics. Heat natural flows from hot to cold. Work is applied to cool a living space or storage volume by pumping heat from a lower temperature heat source to a higher temperature heat sink. The operating principle of this cycle was mathematically described by said Carnot in 1824 as a heat engine.

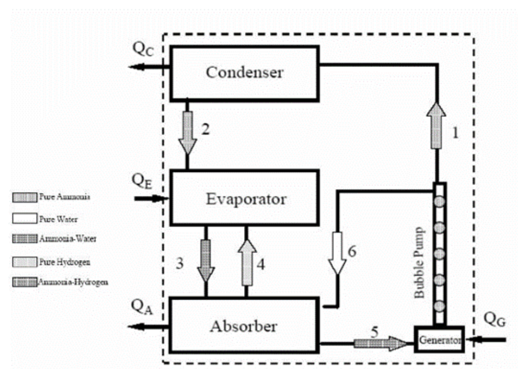

Fig. 1. Cyclic-refrigeration system

The most common type of refrigeration cycle uses the reverse Rankin vapor compression refrigeration cycle although absorb heat pump is used.

Vapour Refrigeration Cycle

- Vapour compression refrigeration cycle
- Vapour absorption refrigeration cycle

3) Vapour Compression Refrigeration Cycle

Most common refrigeration cycle in use today. There are four principal control volumes involving these components:

- Evaporator
- Compressor
- Condenser
- Expansion valve

All energy transfers by work and heat are taken as positive in the directions of the arrows on the schematic and energy balances are written accordingly.

The processes of this cycle are,

1. Process 4-1: Two-phase liquid-vapor mixture of refrigerant evaporates through heat transfer from the refrigerated space.

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2. Process 1-2: Vapour refrigerant is compressed to a relatively high temperature and pressure requiring work input.
3. Process 2-3: Vapour refrigerant condenses to liquid through heat transfer to the cooler surroundings.
4. Process 3-4: liquid refrigerant expands to the Evaporator pressure.

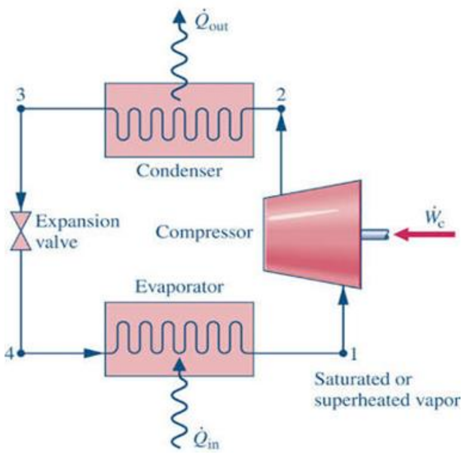

Fig. 2. Vapour compression refrigeration system

4) Vapour Absorption Refrigeration Cycle

The continuous absorption-type 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, condenser, Evaporator, and absorber. The unit can be run on electricity, kerosene or gas. When the unit operates on kerosene or gas the heat is supplied by a burner which is fitted underneath the central tube (A) and when the unit operates on electricity the heat is supplied by a heating element inserted in the pocket (B). The unit charge consists of a quantity of ammonia, water, and hydrogen at a sufficient pressure to condense ammonia at the room temperature for which the unit is designed. When heat is supplied to the boiler system, bubbles of ammonia gas are produced which rise and carry with them quantities of week ammonia solution through the siphon pump (C). This weak solution passes into the tube (D), whilst the ammonia vapor passes into the vapor pipe (E) and on to the water separator. Here any water vapor is condensed and run back into the boiler system leaving the dry ammonia vapor to pass to the condenser. Air circulating over the fins of the condenser removes heat from ammonia vapor to cause it to condense to liquid ammonia in which state it flows into the Evaporator. The Evaporator is supplied with hydrogen. The hydrogen passes across the surface of the ammonia and lowers the ammonia vapor pressure sufficiently to allow the liquid ammonia to evaporate.

The evaporation of the ammonia extracts heat from the food storage space, as described above, thereby lowers the temperature inside the refrigerator. The mixture of ammonia and hydrogen vapor passes from the Evaporator to the absorber. Entering the upper portion of the absorber is a continuous trickle of weak ammonia solution fed by gravity from the tube (D). This weak solution, flowing down through the absorber comes into contact with the mixed ammonia and hydrogen gases which readily absorb the ammonia from the mixture leaving the hydrogen-free to rise through the absorber coil and to return to Evaporator. The hydrogen thus circulates continuously between the absorber and the Evaporator. The strong ammonia solution produced in the absorber flow down to the absorber vessel and thence to the boiler system, thus completing the full cycle of operation. The liquid circulation of the unit is purely gravitational. Heat must also be dissipated from the condenser in order to cool ammonia 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 a paramount improvement that this heat is kept within 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 a welded joint. 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-Maunters system offers low COP due to energy requirement in the bubble pump and also due to losses in the evaporator because of the presence of the hydrogen gas. In addition, since the circulation of fluid inside the system is due to buoyancy and gravity, the heat and mass transfer coefficient is relatively small, further reducing the efficiency.

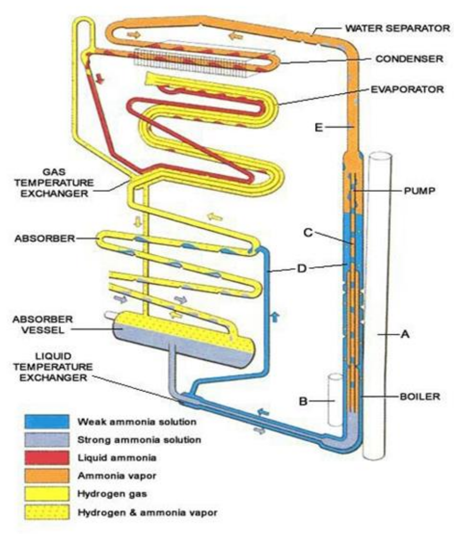

Fig. 3. VARS schematic diagram

2. Literature review

Aman Shukla et. al. [1] C.O.P derivation and thermodynamic calculation of ammonia-water vapor absorption refrigeration system. To use the excessive heat from boiler or non-

Table 1
Experimental value of various literature

Parameter	Aman Shukla, Abhishek Mishra, Devesh Shukla, Karan Chauhan	V. Srikanth, B. Raja Narender and Dr. AVSSKS Gupta	K Karthik	Nikunj Valand, MIthik Kachhiya, Rajdeepsinh Thakor
Refrigerant	Ammonia	Ammonia	Ammonia	Ammonia
Capacity(kW)	3.788	1.301	0.01562	1.333
Temperature, °C	66-99	135	90	84
C.O.P.	0.598	0.750	0.1675	0.696

conventional power resources like solar power to input in vapor absorption refrigeration system (VARS). The objective is to study C.O.P. of the VARS cycle. COP of the system is greatly influenced upon the system temperature, like condenser, evaporator, generator and absorber temperature.

V. Srikanth et. al. [2] Thermodynamic analysis of vapor absorption refrigeration system using solar energy. To study the different properties of ammonia and ammonia mixed water like specific enthalpy, specific entropy and specific Volume at different temperatures. The COP of the cycle is obtaining at the constant pressure and temperature. With an increase in ammonia concentration, generator outlet and COP is slightly decreased.

K Karthik et. al. [3] Design, fabrication, and analysis of solar vapor absorption refrigeration system. This paper is based on an Electrolux refrigeration system using solar energy as input. The principle behind Electrolux refrigeration is that it uses three gases to accomplish its cooling effect namely ammonia (refrigerant) water (absorbent) and hydrogen. It is able to make an equation that used to calculate different parameters of the refrigeration system.

Nikunj et. al. [4] Modification of Generator in Electrolux refrigeration. The objective of this paper is to do modification in a generator-heat exchanger in a convectional vapor absorption system by using the natural resources as the heat input in the generator. So for that, the conventional burner heated or electrically heated generator is replaced by a solar collector which supplies the heat absorbed on it the heat exchanger where the mixture of liquid ammonia and water get heated and the vapor ammonia is generated which is supplied for further process. Where they found the feasibility of water solar collector for the VAR system to produce enough cooling effect.

1) Conclusion from the Literature review

We derived a conclusion from all the above literature is that high temperature is required to achieve high cooling effect.

Where all data can be shown under certain several different criteria and circumstances.

3. Aim, objective & problem definition

Aim

To fabricate a refrigeration system that uses solar energy to heat the refrigerant and produce the cooling in the vapor absorption system.

Objective

- The objective of this project is to develop a vapor absorption refrigeration system using solar heat using oil as a heat-carrying medium
- To produce the cooling effect at a cheaper cost with better reliability.

A. Problem Definition

The fabrication of the facility including a generator to absorb the solar heat by use of oil and development of solar collectors to absorb the solar radiation and use it to heat the oil.

Use of insulation to prevent heat loss during energy transfer from a solar collector or to oil and regenerator.

4. Results and discussion

VAR system works with the help of solar heat, where heat energy is collected by using the solar collector. Heat exchanger absorbs heat from the heat collected region, which is made of high thermal conductive material of copper that, transfers heat easily to the oil and increases the temperature of the oil.

Where generator transfers heat from high-temperature oil to the aqua-ammonia composition as a heat transfer mode of conduction and convection. That separates ammonia from the aqua-ammonia composition and heated ammonia passes inside the absorption system and produce a cooling effect. Reading of all components is shown below with considering all parameters like oil and temperature at various times during day time.

Readings of the electricity based VARS give a brief idea for the future work, that how much temperature needed to achieve at several parts of the VARS.

Table 2
Electrically operated VARS Reading (10/02/2019)

10/2/2019	T1	T2	T3	T4	T5	T6	T7
10:47 am	27	26.8	26.9	26.8	27.5	26.7	27.1
11:20 am	129	71.5	27	27	27.8	26.8	27.6
11:40 am	134	73.5	35.3	30.7	28.5	23.8	28.9
12:00 pm	134	73.3	34.6	31.9	29.8	11.3	25.2
12:20 pm	139	81.7	37.6	35.8	32.3	5.3	22.9
12:40 pm	137	78.2	35.9	33.3	31.1	2.7	21.3
1:00 pm	137	76.8	35.7	33.2	30.9	1.9	20.3

Table 3
Solar operated VARS (Fluid: Water)

Time	Solar collector	Fluid (oil)
1:20 pm	117	51
1:40 pm	120	58
2:00 pm	133	65
2:20 pm	128	62
2:40 pm	128	60
3:00 pm	122	60
3:20 pm	119	59

We conclude from above table that; water has low heat carrying capacity. Due to that, we could not achieve as much amount of heat which required for working of VARS system.

According to the table, oil has slightly more heat capacity compared to water but that cannot satisfy the requirement. So that, we refuse to use it and find another fluid as a working fluid whose, heat carrying capacity as well as heat transfer capacity is more compared to used oil.

Table 4
Solar operated VARS (Fluid: Oil)

Time	Solar collector, °C	Fluid (water), °C
1:20 pm	110	40
1:40 pm	113	42
2:00 pm	115	45
2:20 pm	122	50
2:40 pm	120	49
3:00 pm	115	47
3:20 pm	110	48

Table 5
Solar operated VARS (Fluid: Engine oil)

28/01/2019	Solar Collector	Oil Tank	Evaporator	Cabin
9:00 am	40	27	18	18
9:30 am	79	38	20.1	19.5
10:00 am	85	44.1	21.7	22.5
10:30 am	90	48	22.9	23.5
11:00 am	104	52.3	24	23.7
11:30 am	110	55	26.2	25.3
12:00 pm	113	63.6	27	27.1
12:30 pm	115	69.7	28.8	28.9
1:00 pm	118	72.2	30.1	30.2
1:30 pm	123	73	31.9	31.8
2:00 pm	117	73.2	33.4	33.1
2:30 pm	110	69.6	33.6	33.5
3:00 pm	105	68.5	32.9	32.8
3:30 pm	103	66.9	32.5	32.5
4:00 pm	99	65.9	31.4	31.2

Table 6
Solar operated VARS (Fluid: Cotton seed Oil)

3/2/2019	Solar Collector	Oil Tank	Evaporator	Cabin
9:00 am	40	28	18	18
9:30 am	79	50	20.1	19.5
10:00 am	85	55	21.7	22.5
10:30 am	90	60	22.9	23.5
11:00 am	104	69	24	23.7
11:30 am	110	71	26.2	25.3
12:00 pm	113	79	27	27.1
12:30 pm	115	84	28.8	28.9
1:00 pm	118	89	30.1	30.2
1:30 pm	123	93	31.9	31.8
2:00 pm	117	91	33.4	33.1
2:30 pm	110	89	33.6	33.5
3:00 pm	105	85	32.9	32.8
3:30 pm	103	79	32.5	32.5
4:00 pm	99	70	31.4	31.2

5. Conclusion

From our project work we conclude that, VARS works ecofriendly as well as without using electricity. However, it requires sufficient temperature for working of system properly. Where oil is use as a medium to store and transfer heat from heat collector to generator, hence it requires leak proof joint at generator and collector. Achieve sufficient Temperature. is the major issue to obtain effective result. Where we tackle that issue but due to unwanted circumstances system do not work properly.

Where, we used water as a working fluid for heat transfer from solar collector to generator for separates ammonia from aqua ammonia composition. But water could not sustain much amount of heat because of lower heat transfer coefficient of water compared to oil. Also, it is having low boiling temperature due to that, water evaporates before achieve required temperature.

Engine oil is used as a working fluid in place of water, where oil has good characteristic of heat carrying and high viscosity. So that, temperature is achieved more compared to water but we could not achieve as required temperature. Because of, high viscosity and more heat carrying capacity. So that, oil could not transfer heat quickly to the generator. Then after, another need is raised to replace engine oil with another fluid which have good characteristic and satisfy all requirements.

Finally, cotton seed oil is chosen for working fluid because we achieved more temperature and transfer heat from collector to generator by using cotton seed oil.

At the end, we could not achieve refrigeration effect because of leakage and fluctuation of heat source due to cloudy atmosphere. So that, project does not work properly but we achieve temperature as per requirements.

6. Future scope

Generation of solar energy has tremendous scope in India compare to other country. The geographical location of the country stands to its benefits for generating solar energy. Which will help us through many ways by replacing that energy with core energy sources.

VARS is totally depend upon rate of heat energy supplied to the generator so, if generator temperature is more than we achieve more cooling effect. For that, find possible and best ways to absorb heat energy from the solar radiation and transfer that heat energy to the generator. For example, by using of evacuated tube, Fresnel lens, proper and sufficient amount of insulation to reduce heat loss, and so on parameters can be considered. Then after, fabricate that components in a proper way to achieve more cooling effect and more efficiency. Most of the industries exhausting their flue gases with higher heat content which leads to thermal pollution of the globe and it results in global warming. This heat source can be applied to VAR system which produce cooling effect. Through this we can obtain sufficient temperature from waste heat due to that we reduce incremental rate of global warming from rejected heat.

References

[1] Aman Shukla, Abhishek Mishra, Devesh Shukla, Karan Chauhan, C.O.P derivation and thermodynamic calculation of ammonia-water vapour absorption refrigeration system., IJMET, Volume 6, page no. 78, May 2005.

[2] V. Srikanth, B. Raja Narender and AVSSKS Gupta, Thermodynamic analysis of vapour absorption refrigeration system using solar energy. IJLTEAT, Volume 7, pp. 17-26.

[3] K Karthik et.al. Design, fabrication and analysis of solar vapour absorption refrigeration system. IJETAE, Volume 4, page no. 435-440, September 2014.

[4] R. S. Khurmi and Gupta (1987) 'A Textbook of Refrigeration and Air Conditioning', S. Chand Publication. Reprint 2009, multicolor illustrative Edition.

[5] Nikunj Valand, MIthik Kachhiya, Rajdeepsinh Thakor, "Modification of Generator in Electrolux refrigeration," IRJET, volume 4, Feb. 2007.