Operate A Vapour Absorption Refrigeration System By Using Solar Energy

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Abstract- *Solar energy which is most abundant source of energy in India and we have not having efficient technology to tap this energy source into varied application. So our primary focus of this project would be utilizing solar energy for design and study environmental friendly vapour absorption refrigeration system. The vapour absorption system is two fluid system comprising of ammonia and water and it has three phases: Evaporation, Absorption, and Regeneration. Here in this Refrigeration system when low boiling point refrigerant evaporate, it takes some heat away with it providing the cooling effect and changes gas back into liquid. In this system compressor is replaced by generator and Absorber.*

Keywords- Bond Strength, CFST column, concrete compressive strength and steel tube using ANSYS

I. INTRODUCTION

Vapour Absorption Refrigeration Systems (VARS) belong to the class of vapour cycles similar to vapour compression refrigeration systems. However, unlike vapour compression refrigeration systems, the required input to absorption systems is in the form of heat. Hence these systems are also called as heat operated or thermal energy driven systems.

1.1. Refrigeration:

It is process of removal of heat and reducing as well as maintaining temperature below surrounding temperature. Unit of refrigeration is tons of refrigeration.

Refrigeration is the process of cooling a space or substance below environmental temperatures. Refrigeration was done primarily using methods similar to those mentioned above until the initiation of the commercial refrigerator in 1856 by Alexander Twinning. Oliver Evans designed the first refrigeration machine, or refrigerator, in 1805; but it was John Gorrie who produced the first working model. Gorrie created a refrigeration effect by compressing a gas, cooling it through radiating coils, and expanding it to lower the temperature further. It is this method of refrigeration that is most widely used today and is known as the vapor-compression process.

1.2 Refrigerator

It is device used to maintain temperature below surrounding temperature within require space. Here in case of refrigerator, we are interested to maintain temperature T1<T2 where T2 is the atmospheric temperature and for going doing so most economically, maximum Q must be taken from sink with minimum amount of W. So that performance of refrigerator is taken into account by a ratio Q/W and it is known as coefficient of performance (COP).

COP = Q/w

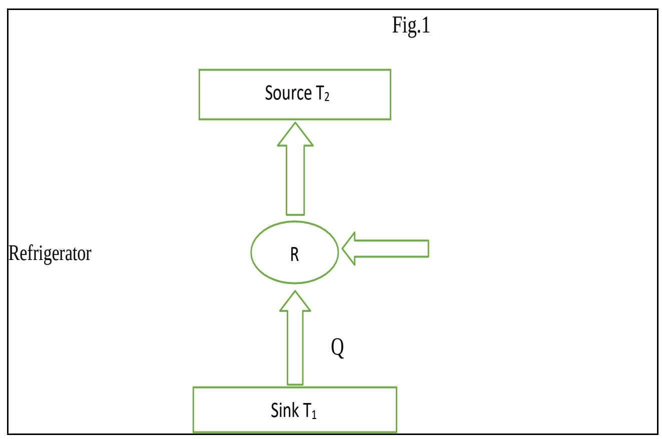


Figure 1.1: Refrigerator system

1.3 Method of Refrigeration

1. Ice refrigeration
2. Evaporative refrigeration
3. Refrigeration by expansion of air
4. Refrigeration by throttling of gas
5. Steam jet Refrigeration system
6. Dry ice Refrigeration
7. Non-Cyclic Refrigeration
8. Cyclic Refrigeration
    a. Vapour Compression Refrigeration
    b. Vapour absorption Refrigeration

c. Gas cycle
9. Thermoelectric Refrigeration
10. Magnetic Refrigeration
11. Air refrigeration

II. PROBLEM STATEMENT

Though absorption refrigeration system is an ideal way to combat energy consumption of refrigeration sector, it suffers some serious faults like:

1. Low COP

Ideally speaking COP of an absorption refrigeration system is about 2.0. But in reality it is less than 1.

2. Large Size & huge weight

They are much more complex than a normal refrigerator and occupy a huge space. They require much larger cooling towers to reject the waste heat owing to their low COPs, and thus servicing them is not less than a nightmare.

3. High cost

The absorption refrigeration systems are much more expensive than the vapor- compression refrigeration systems which are quite obvious as their cost of production is high because of complex and large parts. This also makes them difficult to service.

III. PROPOSED OBJECTIVES

- To make effective refrigeration making use of Solar Energy.
- One time investment with minimum running expense.
- Pollution Free system.
- Refrigeration system having “Low Maintenance Cost”.
- Use of Low Grade Energy
- Least Leakage of Refrigerant
- Stepless Capacity Control
- Less Power Consumption Device

IV. RESEARCH METHODOLOGY

COMPARISION OF VAR AND VCR

Absorption system	Compression system
a) Uses low grade energy like heat. Therefore, may be worked on exhaust systems from I.C engines, etc.	a) Using high-grade energy like mechanical work.
b) Moving parts are only in the pump, which is a small element of the system. Hence operation is smooth.	b) Moving parts are in the compressor. Therefore, more wear, tear and noise.
c) The system can work on lower evaporator pressures also without affecting the COP.	c) The COP decreases considerably with decrease in evaporator pressure.
d) No effect of reducing the load on performance.	d) Performance is adversely affected at partial loads.
e) Liquid traces of refrigerant present in piping at the exit of evaporator constitute no danger.	e) Liquid traces in suction line may damage the compressor.
f) Automatic operation for controlling the capacity is easy.	f) It is difficult.
g) In the absorption refrigeration system there are no major moving parts hence they don’t vibrate, don’t make noise.	g) The compressor of the vapor compression system is operated at very high speeds and it makes lots of vibrations and noise.
h) It doesn’t require heavy foundations. The absorption refrigeration systems operate silently.	h) It requires very strong foundation so that it can remain intact under vibrations and high pressures of the refrigerant.

4.1. Components of vapour absorption system

- Condenser
- Evaporator
- Generator
- Absorber

4.2. Properties Require For Refrigerant-Absor- Bent Mixture

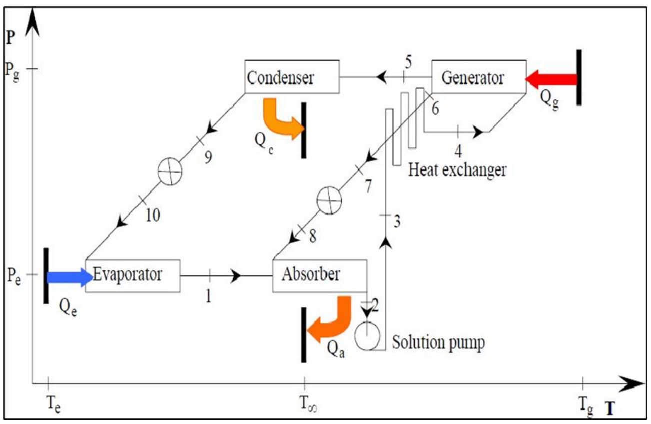
1. The refrigerant should exhibit high solubility with solution in the absorber.
2. There should be large difference in the boiling points of refrigerant and absorbent (greater than 200oC), so that only refrigerant is boiled-off in the generator. This ensures that only pure refrigerant circulates through refrigerant circuit (condenser-expansion valve-evaporator) leading to isothermal heat transfer in evaporator and condenser.
3. It should exhibit small heat of mixing so that a high COP can be achieved.
4. The refrigerant-absorbent mixture should have high thermal conductivity and low viscosity for high performance.
5. It should not undergo crystallization or solidification inside the system.
6. The mixture should be safe, chemically stable, non-corrosive, inexpensive and should be available easily.

4.3. Process Description

- Figure shows a basic vapour absorption refrigeration system with a solution heat exchanger on a pressure Vs temperature diagram. As shown in the figure, low temperature and low pressure refrigerant vapour from evaporator at state 1 enters the absorber and is absorbed by solution weak in refrigerant (state 8).

The heat of absorption (Qa) is rejected to an external heat sink at To.

- The solution, rich in refrigerant (state 2) is pumped to the generator pressure (Pg) by the solution pump (state 3). The pressurized solution gets heated up sensibly as it flows through the solution heat exchanger by extracting heat from hot solution coming from generator (state 4).
- Heat is supplied to this solution from an external heat source in the generator (Qg at Tg), as a result refrigerant vapour is generated (absorbent may also boil to give off vapour in case of ammonia-water systems) at state 5.
- This high-pressure refrigerant vapour condenses in the condenser by rejecting heat of condensation to the external heat sink (Qc at To) and leaves the condenser as a high pressure liquid (state 9).
- This high pressure refrigerant liquid is throttled in the expansion device to evaporator pressure P (state 10) from where it enters the evaporator, extracts heat from low temperature heat source (Q at T) and leaves the evaporator as vapor at state 1, completing a cycle.
- The hot solution that is weak in refrigerant (state 6) leaves the generator at high temperature and is cooled sensibly by rejecting heat to the solution going to the generator in the solution heat exchanger (state 7). Then it is throttled to the evaporator pressure in the throttle valve (state 8), from where it enters the absorber to complete the cycle.
- It can be seen that though not an essential component, the solution heat exchanger is used in practical systems to improve the COP by reducing the heat input in the generator.
- As a result of this heat exchange, less heat input is required in the generator and less heat is rejected in the absorber, thus improving the system performance significantly.



4.4. Advantages Of VAR

1) **Method of compression of the refrigerant**: One of the most important parts of any refrigeration cycle is the compression of the refrigerant since all the further operations depend on it. In the vapor compression refrigeration system the compression of the refrigerant is done by compressor which can be of reciprocating, rotating or centrifugal type. In the vapor absorption refrigeration system, the compression of the refrigerant is done by absorption of the refrigerant by the absorbent. As the refrigerant is absorbed, it gets converted from the vapor state to liquid state so its volume reduces.
2) **Power consumption devices**: In the vapor compression cycle the compressor is the major power consuming device while in the vapor absorption cycle the pump used for pumping refrigerant absorbent solution is the major power consuming device.
3) **The amount of power required:** The compressor of the vapor compression cycle requires large quantities of power for its operation and it increases as the size of the refrigeration system increases. In case of the vapor absorption refrigeration system, the pump requires very small amount of power and it remains almost the same (or may increase slightly) even for higher capacities of refrigeration. Thus the power consumed by the vapor absorption refrigeration system is much more than that required by the vapor compression system.
4) **Type of energy required:** The vapor absorption system runs mainly on the waste or the extra heat in the plant. Thus one can utilize the extra steam from the boiler, or generate extra steam for the purpose and also use the hot available water. Similarly the waste heat from the diesel engine, hot water from the solar water heater, etc. can also be utilized. In case of the vapor compression refrigeration system, the compressor can be run by electric power supply only; No other types of energy can be utilized in these systems.
5) **Running cost:** The vapor compression refrigeration system can run only on electric power, and they require large amount of power. These days the electric power has become very expensive, hence the running cost of the vapor compression refrigeration system is very high. In case of the absorption refrigeration system only small pump requires electric power and it is quite low. In most of the process industries, where the absorption refrigeration is used, there is some extra steam available from the boiler, which can be used for running the system. Thus in absorption refrigeration system no extra power in the pure electric form is required and the energy that would have otherwise gone wasted is utilized in the plant. Thus the running cost of the absorption refrigeration system is much lesser than the vapor compression system.

6) **Capacity control of the system:** In the vapor compression cycle the capacity control of the system is done from the compressor and in most of the cases stepwise capacity control is obtained. In case of the absorption refrigeration system it is possible to obtain stepless capacity control and zero capacity when there is no load on the system. Though these days compressors with stepless capacity control are available, but they will consume lots of power even if there is zero load on the refrigeration system. In absorption system, when there is zero load the power consumption is almost zero.
7) **Maintenance**: Compressor is the crucial part of the vapor compression cycle, and it has number of moving parts. It is very important to do the thorough lubrication of the compressor and also keep checking it regularly for any defects. The compressor also requires changing of the piston, piston rings, cylinder liner etc. from time to time. Thus the vapor compression system requires lots of maintenance. Failure of compressor can be very expensive at times as the suction and the discharge valve of the compressor are very expensive. Even the motor of the compressor is very heavy and expensive. The compressor also requires cooling, for which special pump is required to pump the water from the cooling tower to the compressor. Since there are number of moving parts of the compressor that move at very fast speed some or the other failure occurs regularly. In the absorption refrigeration system the only moving part is the small pump that fails rarely. Thus the maintenance required by the vapor compression system is much more than that required by the vapor absorption system.
8) **Type of refrigerant used and its cost:** In ammonia water absorption refrigeration system, ammonia is used as the refrigerant, which is easily and cheaply available. In lithium bromide system, water is used as the refrigerant, which is also available cheaply and easily. In case of the vapor compression refrigeration system halocarbons are used as the refrigerants, which are very expensive.
9) **Leakage of the refrigerant:** In the absorption refrigeration system there are no (or very few) leakages of the refrigerant and the refrigerant itself is very cheap. Thus there are almost zero refrigerant recharging costs. In case of the vapor compression systems there are lots of leakages of the refrigerant thus regular recharge of the refrigerant is required which is very expensive.
10) **Greenhouse effect**: Most of the halocarbon refrigerants used in the compression refrigeration system produces greenhouse effect. As per the Montreal Protocol, their use has to stop completely by the year 2020.

4.5. Application Of VAR

- For domestic purpose
- In medical store for storage of medicine
- For storage of dairy item
- In industries
- In planes ,trains and limousine cars
- For storage of the blood
- It is used in research laboratories
- It is used by shopkeepers

V. DESIGN OF THE COMPONENTS

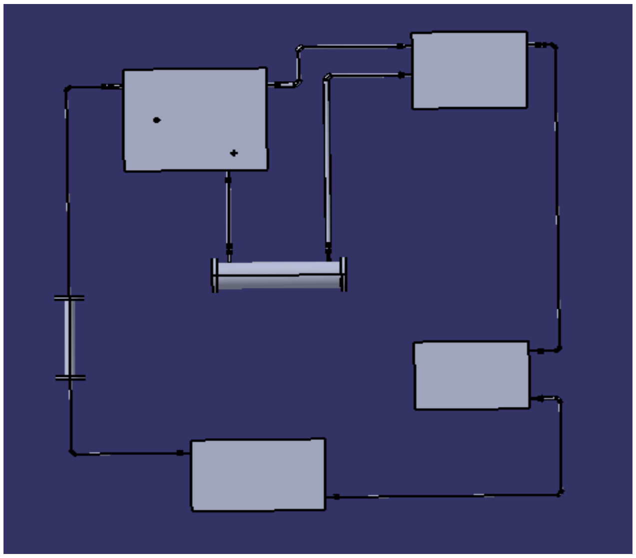
5.1. ANSYS-Fluent Heat Exchanger

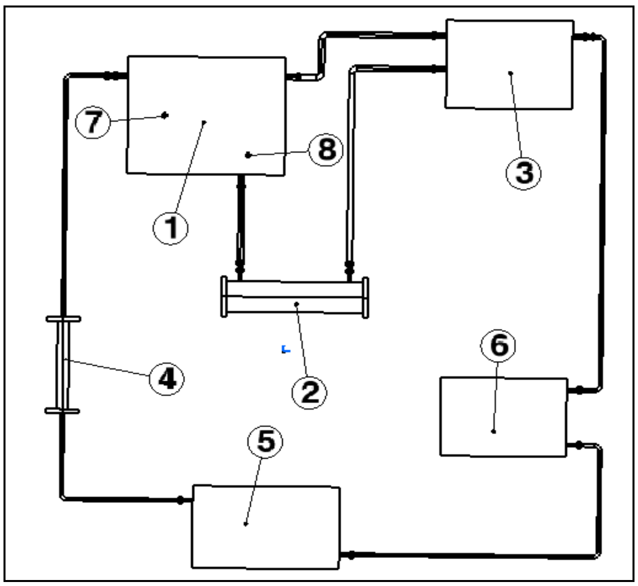
Table Chart of Model dimensions

Descriptions	Generator	Condenser	Evaporator	Absorber	Heat Exchanger
Tube diameter (mm)	ϕ 25	ϕ 15	ϕ 15	ϕ 25	ϕ 10
Tube thickness (mm)	2	2	2	2	2
Dimensions (L× W × H) (mm)	50×12×12	50×450×420	90×250×240	70×600×450	-
Tube length (m)	3.5	14.6	9.1	12.5	35.5
Inside area (m^2)	-	0.69	0.429	0.98	
Outside area (m^2)	0.3	9	4.7	11.6	1.34
No. of tube	4	32.4 =32	36.4 = 36	28	
No. of tube row		2.3 = 2	4.2 = 4	2	
No. of tube per row		16.4 =16	9.4 = 9	14.8	
Inside coefficient (W/m^2k)	42289.5	7531.6	7410.4	44858	4324.6
Outside coefficient (W/m^2k)	117.7	92.4	70	77.6	4605
No. of fins	-	252	158	205	
Thickness of fins (mm)	-	0.16	0.126	0.15	
Space of fins (mm)	-	1.62	1.5	2	
Shell diameter (mm)					156
Shell length (mm)					234
Weight (kg)	2.2	9	5.5	12.15	9.6

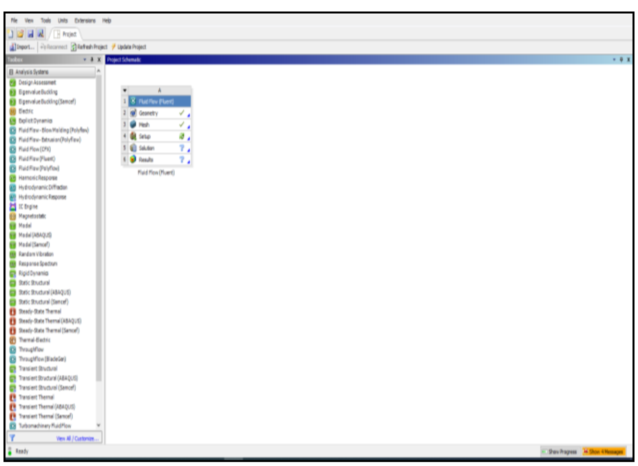
5.2. Vapour Absorption System Cad Model In CATIA V5

SR.NO	PART NAME
01	EVAPORATOR
02	GENERATOR
03	REFREGERATOR
04	EXPANSION VALVE
05	ABSORBER
06	CONDENSOR
07	INLET
08	OUTLET

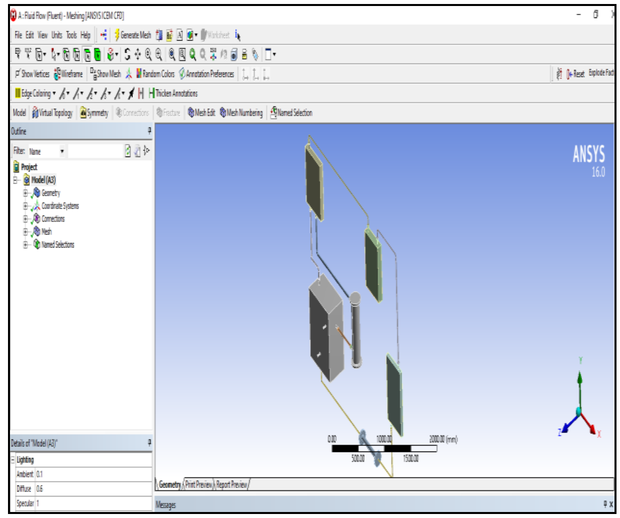




Step 1: Create ANSYS-Fluent



Step 2: Create Model in Ansys-Fluent



5.3. ANSYS Parametric Solid Model

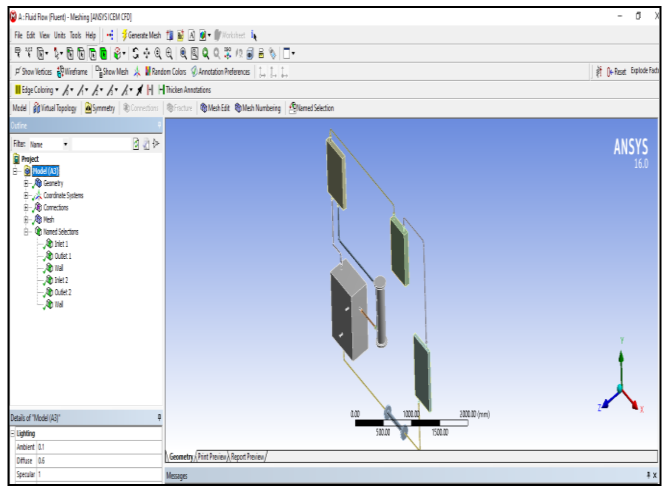


Fig. VAR Model in ANSYS

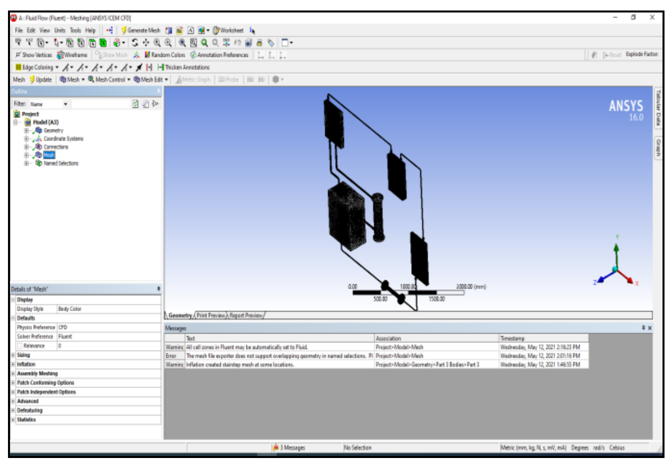


Fig. Meshing of Model

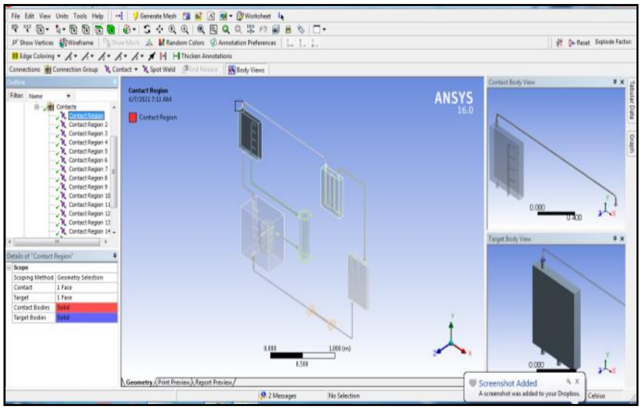


Fig. VAR System contact connections

VI. RESULTS

Table. Variation of bottom cabinet temperature

Variation of bottom cabinet temperature w.r.to time in VAR		
Time	Grid Supply	PV Supply
12:00	30.1	32.81
12:10	25.6	27.89
12:20	21.7	23.70
12:30	18.5	20.15
12:40	15.7	17.13
12:50	13.4	14.96
13:00	11.4	12.71
13:10	9.6	7.62
13:20	8.2	6.48
13:30	7.0	5.51
13:40	5.9	4.68
13:50	5.0	3.98
14:00	4.3	3.38
14:10	3.6	2.88
14:20	3.1	2.44
14:30	2.6	2.08
14:40	2.2	1.77
14:50	1.9	1.50

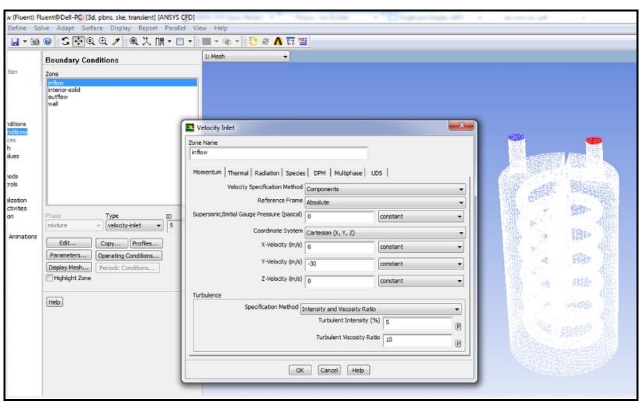


Fig. Add inflow parameters

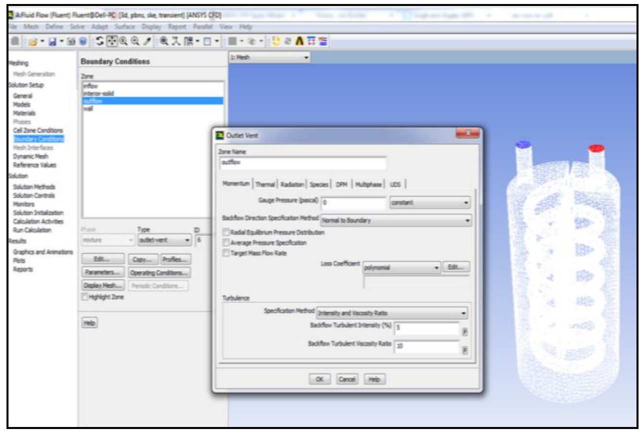


Fig. Outflow Parameters

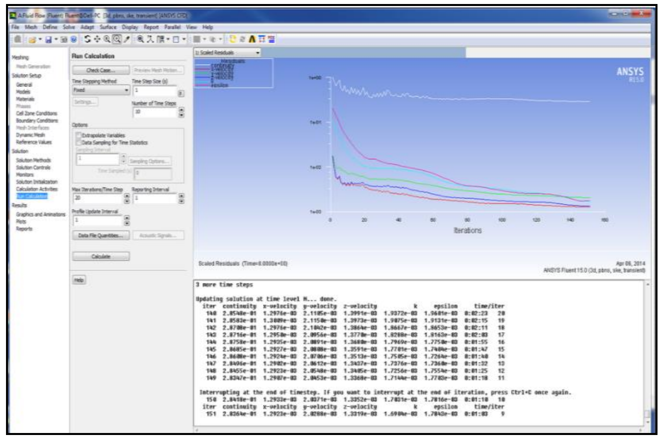


Fig. Model Simulation

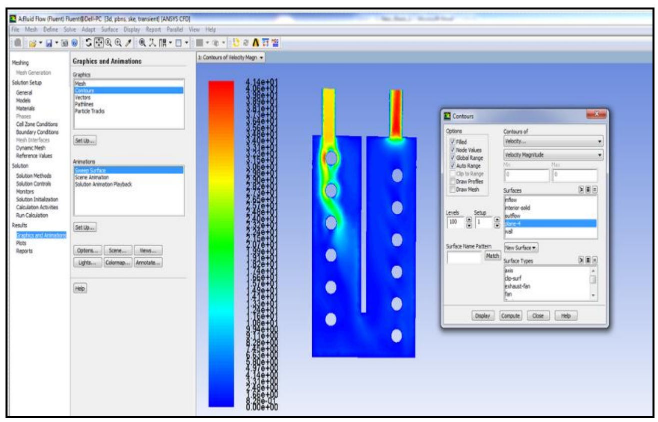
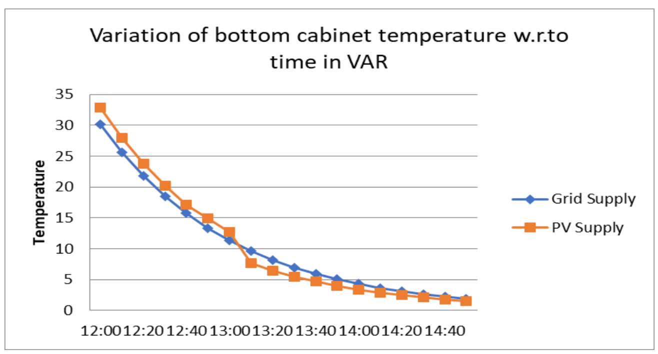


Fig. Model Analysis Results



Shows the variation of bottom cabinet temperature of the refrigerator which works on vapour absorption principle. In the vapour absorption refrigerator it is noted that in the beginning for half an hour temperature increases after that temperature continuously decreases.

VII. COSTING AND ESTIMATION

7.1 Costing of Different Component

Sr. no	Components	Quantity	Price
1	Mild Steel pipe	25 feet	Rs 660
2	Galvanized iron sheet	1	Rs 1200
3	Welding	5	Rs 150
4	Pump	1	Rs 700
5	Capillary tube	1	Rs 300
6	Soldering	9	Rs 100
7	Other cost	8	Rs 500
8	Total Cost	-	Rs 3610

7.2 Cost of Solar Panel

Products	Inputs / Watt	Price / INR
Thin Film Multi SPV	100W	Rs. 32/W
SPV Mono	10W	Rs. 53/W
SPV Multi	10W	Rs. 50/W
Special SPV Mono	180W / 190W	Rs. 34/W
SPV Mono	20W - 30W	Rs. 43/W
SPV Multi	20W - 30W	Rs. 40/W
Special SPV Multi	230W,240W, 245W, 280W,290W	Rs. 32/W
SPV Mono	30W - 300W	Rs. 41/W
SPV Multi	30W - 300W	Rs. 38/W

VIII. CONCLUSION AND RECOMMANDATION

8.1 CONCLUSION

- As variation of bottom cabinet temperature of the refrigerator which works on vapour absorption principle.
- In the vapour absorption refrigerator it is noted that in the beginning for half an hour temperature increases after that temperature continuously decreases.
- So it is technically feasible to operate refrigerator VARS as photovoltaic refrigerators under normal operating conditions both refrigerators working on photovoltaic power supply, behave similar to working on grid electricity.
- Performance test shows that vapour compression refrigerator system has a very high cooling rate and more power consumption in comparison to vapour absorption refrigeration system.
- The VAR system has low capital cost. The VARS can be used for preserving the drugs and medicine in the remote areas where no more cooling is required only temperature is to be maintained.
- It may be recommended that if a high cooling rate is required frequently one should select vapour compression refrigeration system and if only the temperature is to be maintained in the cabinet then the vapour absorption system is capable with less capital investment than compression system.
- The Vapour absorption system also performs noise free operation with less maintenance cost.

8.2 RECOMMANDATION

The simulation studies have been done in a very simple way by using grid supply and PV supply, and research conclude that if a high cooling rate is required frequently one should select grid supply instead of PV supply because PV supply fluctuate in high cooling, If want to use PV supply for high cooling It may be recommended to use Inverter or battery power backup for stabilize supply.

REFERENCES

[1] Lesson on vapour absorption refrigeration system by IIT kharagpur

[2] Research paper published by university of malda, msida, MSD 2080 MALTA

[3] www.brighthubengineering.com

[4] Analysis of vapour absorption refrigeration system by Shubham Srivastava, Ravi Kumar Sen, Arpit Thakur, Manish Kumar M.Tech, Mechanical Engineering, Lovely Professional University, Punjab, India

[5] Vapour absorption refrigeration system using law grade energy-an Eco Friendly approach by V.R.Renjith And P.J.Joshy department of mechanical engineering cochin university of science and technology

[6] Design of solar water cooler using aqua ammonia Absorption refrigeration system R Sai Lavanya, Dr.B.S.R.Murthy Department of Mechanical Engineering, QIS College of Engineering & Technology Ongole – 523272, Andhra Pradesh, India.

[7] International Journal of Engineering Research & Technology (IJERT) Vol. 1 Issue 8, October - 2012 ISSN: 2278-0181.