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FOOD PRESERVATION USING SOLAR REFRIGERATION

Prabakaran S
M.E. Thermal Engineering
Anna University Regional Campus - Tirunelveli
Tamil Nadu, India
prabasankar1506@gmail.com

Rajesh.K
M.E. Thermal Engineering
Anna University Regional Campus - Tirunelveli
Tamil Nadu, India

Sakthinathan G
Associate Professor & Dean
Anna University Regional Campus - Tirunelveli
Tamil Nadu, India
gsakthinathan@yahoo.com

***Abstract*— A solar vapour compression refrigeration system was designed for preserve the fishes in the boat for cholachal atmospheric conditions. Now a days fisheries using ice bar for preserve the fishes. By using solar refrigeration system can reduce the weight of ice bar and fuel consumption. Intensity and relative humidity are the performance affecting factors of solar refrigeration system. The various affecting factors were analysed due to the change of relative humidity at the seashore. The solar energy is derived by active solar technique. Solar panel is the essential component to generate the electricity from the sun. Solar panels reduce the pollution levels of the atmosphere. Due to solar refrigeration effect we can enhance the quality of fishing and reduce the fuel consumption.**

Keywords*—solar; vapour compression refrigeration; relative humidity

I. Introduction

Air and water, are necessary for the human being to live. All the food used by human being may be obtained from the plant or animal kingdom. All the foods are not produced during the whole year. The different foods are produced at different places and in a particular season. Since some of the foods are required all round the year in various parts of the country, therefore it is essential to preserve them during transportation and subsequent storage until they are finally consumed.

Refrigeration is the process of removing heat from a substance under controlled conditions. Refrigeration means a continued extraction of heat from a body whose temperature is already below the temperature of its surrounding.

Solar energy is radiant light and heat from the sun. Such as solar heating, photovoltaic, solar thermal energy are the various technologies. Solar refrigeration is essential to minimize environmental impact and fuel cost. DC electric power output from photovoltaic drives the compressor of a conventional cycle Analytical Model of Solar Refrigeration System

A. Relative Humidity

Relative humidity is the ratio of actual mass of water vapour in a given volume of moist air. The water content of air at sea level can get as high as 3% by mass at 30°C. Relative humidity is ideal between 50-60% at atmospheric level and 80% at ocean level. It will reduce efficiency of the solar panel and affect the power consumption of solar panels. But however has little effect on output voltage. Increase in current is favored by low relative humidity. And that efficiency is also high during low relative humidity. It is given by,

$$\Phi = P_v / P_s \qquad (1.1)$$

$$P_v = P_w - [(P_b - P_W) * (t_d - t_w)] / [1544 - 1.44\, t_w] \qquad (1.2)$$

Where,

Φ = Relative humidity (%).

P_s = Partial pressure of air corresponding to dry bulb temperature (bar).

P_v = Partial pressure of water vapour (bar).

P_b = Barometric pressure (1.013 bar).

P_w = Saturated pressure corresponding to wet bulb temperature (bar).

t_d = dry bulb temperature (^{0}C).

t_w = wet bulb temperature (^{0}C).

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B. 2 Solar PV Panel Intensity (I)

Intensity is the power transferred per unit area. Intensity of solar radiation is varying with climate change. Efficiency of solar panel is depending upon the intensity of solar radiation. Availability of solar radiation is calculated by,

$$I_b = I_n \cos\theta_z \quad (1.3)$$

Where,

I_b = beam radiation of horizontal surface.

I_n = normal incidence flux.

For Indian conditions there are 300 dust particle/cm^3 at 760 mm of Hg pressure and thickness of ozone layer level is 2.5mm.

$$I_n = 1246/ [1+ (0.3135)\, m]\ w/m^2 \quad (1.4)$$

Where,

m = $\sec\theta_z$, (air mass index)

$I_n = 1246/ [1+ (0.3135) \sec\theta_z]\ w/m^2$

$I_b = 1246/ [1+ (0.3135) \sec\theta_z \cos\theta_z]\ w/m^2$

The beam energy falling on a surface having any orientation, it is necessary to convert the value of the beam flux coming from the sun to an equivalent value corresponding to the surface. Relationships for making this conversions for horizontal surface,

$$\cos\theta_z = \sin\varphi \sin\delta + \cos\varphi \cos\delta \cos\omega.$$

Where,

δ = The angle of declination

The declination δ is the angle made by the line joining the centres of the sun and the earth with its projection on the equatorial plane.

$$\delta = 23.45 \sin [0.9863(284+n)] \quad (1.5)$$

Where,

n = The day of year which varies from n = 1 to 365

φ = latitude of the location

The latitude φ of a location is the angle made by the radial line joining the location to the centre of the earth with the projection of the line on the equatorial plane.

B. Optimum Collector Slope (β)

The slope β is the angle made by the plane surface with the horizontal. It can vary from 0 to 180º.The optimum collector slope is determined from

$$\beta = \delta + \varphi$$

C. Collector Efficiency (η)

Thermal efficiency of the collector

$$\eta_{th} = q_u / [\, I * Ap\,] \quad (1.6)$$

Where,

q_u = useful energy gain (W)

I = Solar insulation (W/m²)

Ap = Area of the absorber plate (m²)

Electrical efficiency of the collector (η_{ele})

$$\eta_{ele} = P_{max} / [Ap * I] \quad (1.7)$$

Where,

P_{max} = Maximum power produced from PV panel (W)

Total efficiency of PV/T collector (η_T)

$$\eta_T = \eta_{th} + \eta_{ele} \quad (1.8)$$

D. Specification of Refrigeration

The thermodynamic efficiency of a refrigeration system depends on the refrigerant selection.

Table-1 *Specifications of Refrigeration System for Refrigerant (R134a)*

s. no	***Properties***	***Value***
1	Boiling point	-26.15ºC
2	Freezing temperature	-101ºC
3	Critical temperature	101.6ºC
4	Critical pressure	40.56 bar
5	COP	4.61
6	Evaporator pressure	1.639bar
7	Condenser pressure	7.708bar
8	Compression ratio	6..72
9	Latent heat	209.5 kJ/kg
10	kW/TR	0.762
11	Specific volume (15ºc)	0.121 m^3/kg

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E. Specifications of fresh fish

The food preservation may be defined as the state in which the food may be retained over a particular time without being affected by pathogenic organism or chemicals and without losing its colour, texture, flavour and nutrition value.

Table-2 properties of fresh fish

s.no	***Properties***	***Fresh fish***
1	Short term storage (temp)	1.1 to 3.3
2	Long term storage (temp)	-1.1 to 0
3	Gravity air circulation (RH)	85
4	Forced air circulation (RH)	80
5	Freezing point (temp)	-2.2
6	Composition in % water	70
7	Maximum storage period	15days

II. Results and Discussion

Enthalpy Distribution of condenser coil

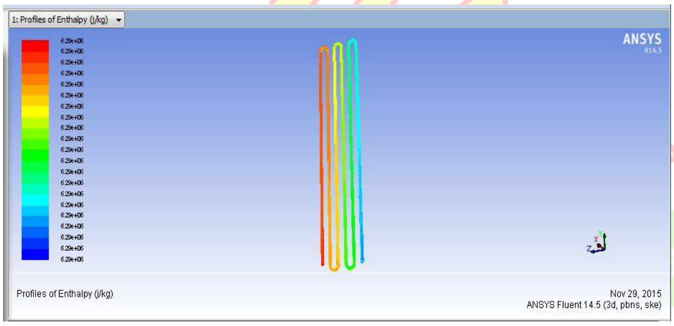

Figure-1 Enthalpy Distribution

The figure 1 shows the enthalpy distribution at 55ºc for refrigerant R134a at 80% relative humidity. The enthalpy at the inlet of the condenser is 423.63 KJ/kg k. The enthalpy at the outlet of the condenser is271.59 KJ/kg k. for the corresponding values pressure of the condenser is 13.177 bar. It is safe level because the critical pressure of R134a is 40.6 bar.

Wet air has higher heat capacity than dry, cold air. Changing the state of refrigerant in the condenser from vapour to liquid by extract heat from the refrigerant. The humidity does affect the capacity of the condenser to a degree, this goes to about misting.

Entropy Distribution of condenser coil

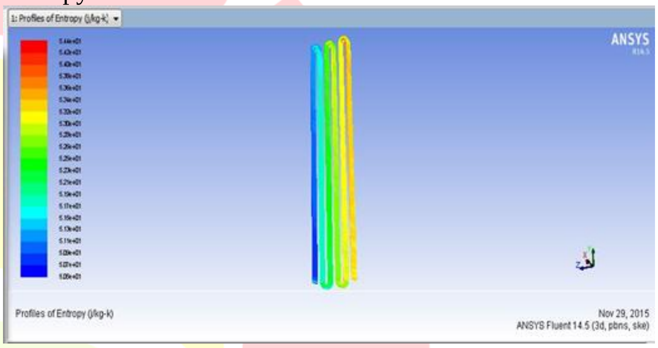

Figure-2 Entropy Distribution

The figure 2 shows the entropy distribution at 50ºc for refrigerant R134a at 80% relative humidity. The entropy at the inlet of the condenser is 1.7078 KJ/kg k. The entropy at the outlet of the condenser is 1.2373 KJ/kg k for the corresponding values pressure of the condenser is 13.177 bar. It is safe level because the critical pressure of R134a is 40.6 bar. In the condenser Coil the refrigerant just rejects its latent heat so the entropy difference between the inlet and outlet less.

Maximum Thermal Efficiency, Useful Heat Gain With Respect to Solar Intensity :

Generally thermal efficiency, useful heat gain of the both collector were increased with increase of solar intensity. The heat gain of the 0.5 m^2 absorber area collector was lower than 2 m^2 absorber area collector, but same time had more efficiency than 2 m^2 absorber area collector. Because huge amount of heat gain was available in small area (185w) compare to 2 m^2 area (563w) for that assumptions made. The useful heat gain was gradually rise in 0.5 m^2 area (88w to 185w) and suddenly increase in 2 m^2 area (268w to 563w).
The figure-3 shows the relation between useful heat gain to the solar intensity. Two absorber collector area 0.5, 2m^2 were compared. The heat gain of the 0.5 m^2 absorber area collector was lower than 2 m^2 absorber area collector.

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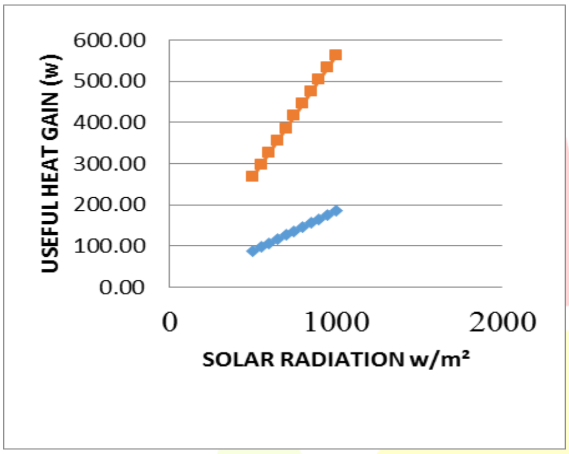

Figure-3 Variation Useful Heat Gain With Respect To Solar Intensity

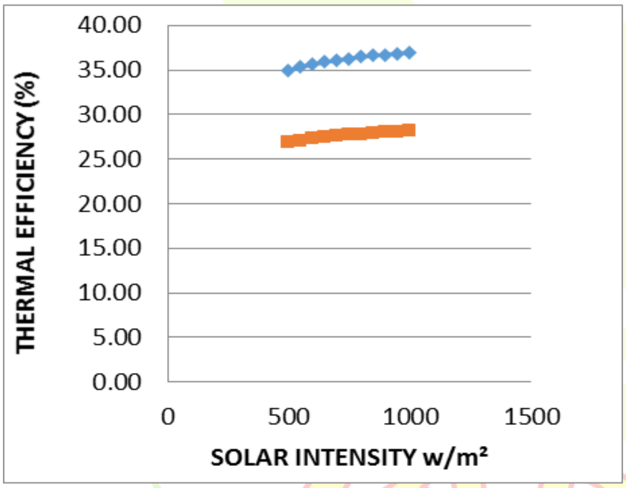

Figure-4 Variation of Thermal Efficiency With Respect To Solar Intensity

The figure-4 shows the relation between thermal efficiency to the solar intensity. Here two absorber collector area 0.5, 2m^2 were compared. The thermal efficiency of the 0.5 m^2 absorber area collector was more than 2 m^2 absorber area collector. Because huge amount of heat gain was available in small area compared to 2m^2.

III. Conclusion

Solar refrigeration system enhance the fishing and reduce the fuel consumption. The parameter to be considered for making solar refrigeration system is intensity and relative humidity.

The intensity of solar radiation is varying with climate change. Efficiency of solar panel is depending upon the intensity of solar radiation. The parameter needed for calculating intensity is declination angle. The declination angle varies from a maximum value +23.45° on June21t a minimum value -23.45° on December 21. Intensity calculation is made for April 15, normal incidence angle In = 766.7 kJ/m2-h. Beam radiation is Ib = 384.5 kJ/m2-h. The optimum collector slope is 30°.

For R134a, the COP of refrigeration system is 4.61, and enthalpy distribution was calculated at 50 °C at condenser, enthalpy at inlet 423.63 kJ/kg k. outlet value is 271.59 kJ/kg k. Entropy value at inlet is 1.7078 kJ/kg k , outlet is 1.2373 kJ/kg k. At sea level relative humidity value is high than ground level. It will increase the condenser temperature and reduce the COP the system. In future work enthalpy and entropy distribution were calculated experimentally for same condition and both results will be compared.

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