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DESIGN OF COIR PEAT INSULATED COLD STORAGESYSTEM FOR 1000KG OF ONIONS

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Abstract* - In India, consumers have a solid inclination for onion. In spite of the fact that they produce a greater number of onions than domestic need, due to lack of cold chain facility and weak supply chain there is a crisis consistently. At the point when onions are collected, they are being cut off from their basis of water and nutrition and before long begin to decay. Conserving the harvested item control the rate of quality and increment the time span of usability. In any case, it's absolutely impossible that the expense of the cold chain drops down. To beat this issue coir peatis utilized as an insulation material to reduce the cost and it is additionally ecologically friendly. Solar PV-system is also used for reducing the electricity cost. In this project, heat load calculation was estimated for selected perishable agricultural product (Onion)on the basis of refrigeration principle, design of grid tied solar assisted cold room using PVsyst, design of coir peat insulated coldstorage system for 1000kg onions.

Keywords: Onion, Cold Chain, Coir Peat, Heat Load, Refrigeration principle, PVsyst.

I. INTRODUCTION

Storage is an art of saving the nature of farming materials and keeping them from disintegration for explicit timeframe, beyond their ordinary time span of usability. Cold storage controls aging retards maturing, mellowing, surface and shading change, impedes dampness misfortune, withering, microbial movement, deterioration, growing and unfortunate development. Accessibility of proper cold storage systems are significant for saving transitory products like milk, meat, eggs, vegetables, organic products, elaborate blossoms and other floricultural merchandise. These cool stockpiles give transient food things a more drawn-out timeframe of realistic usability by keeping them from decaying because of stickiness, high temperature and miniature living beings. This outcomes in decrease in misfortune because of deterioration.

Onion (allium cepa l) is quite possibly the maximum broadly developed vegetable in the world. It is utilized as vegetables in many pieces of the world. The worldwide fare of onion is 64,29,147 metric tons. The significant onion developing tropical nations are India, Pakistan, Indonesia, Bangladesh, Niger, Ethiopia and so forth these nations offer more than 70 % of absolute onion send out. These nations are significant provider of onions to mild nations during the basic hole. There are two particular stockpiling temperature and relative humidity for onion i.e., 0-2 C and 70 % RH and 25-30 C and 70 % RH. The subsequent condition wins in tropical nations which support more stockpiling misfortunes. More over onion is put away under surrounding conditions in tropical districts as the low temperature storerooms are once in a while accessible. Onion can be put away at 0 C and 70-80 percent RH for up to 8-9 months.

A. Principles of Refrigeration

The cool storage like each other refrigerating frameworks of a similar greatness utilizes the vapour compression technique for mechanical refrigeration. Fig.1 presents the T-s chart of the vapour compression cycle respectively.

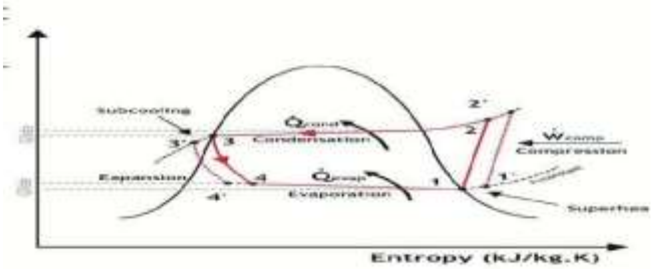

Fig.1. T-s diagram of the vapour

Reduction in cooling loads over careful building design and insulation is desirable and will be fewer expensive than provision of additional cooling. Good building design and construction can decrease the load on any air conditioning or heating system. Need is observed to introduce energy supply, especially, to rural population for increased productivity and income generation. The application of solar energy for refrigeration purposes in the agro-industry has a potential in developing countries. The current scenario of cold storage systems in India and also the losses involved in post-harvest technologies, solar powered VCRS system where been discussed.

II. MATERIALS AND METHODS

The major components involved in the fabrication of the coir peat insulated cold storage system for onions are as follows.

A. Coir pith

A spongy material that quandaries the coconut fiber in the husk, coir pith is finding new applications. It is an brilliant soil conditioner and is being extensively used as a soil-less medium for agro-horticultural purposes. With its moisture retention qualities, coir pith is perfect for growing anthuriums and orchids.

To reduce energy consumption, it is important to use air conditioners effectively. Therefore, it is important to improve thermal insulation materials in order to minimize energy consumption by effectively using air-conditioning for cold storage buildings. Here, we have aimed to reuse the industrial agricultural waste, such as the enormous quantity of coconut fibers discharged after palm fruit extraction from the coconut shells.

Fig.2.1. Coir peat block

The research methodology of this study consists of several tasks which are the Problem statement, literature review, selection of refrigeration system, selection of insulation material, heat load calculations, computational fluid dynamics (CFD) simulation, results and discussions. This work is highlighted at the Modelling and simulation coconut fibre insulation wall using steady state analysis.

B. Cold storage

Cold storage structure: In such types of storage facilities, the onions are stored at 0-5°C and 60-65% RH that mains to much lesser losses as comparative to ventilated storage structure. The cost of construction and running cost are very high as energy essential to maintain the storage facility in the temperature range of 0-5°C is high. The other problems are condensation and need lot of energy and time. The bulbs start sprouting directly after they are removed from the cold storage.

C. Refrigeration unit

Refrigeration, or cooling process, is the elimination of unwanted heat from a selected object, substance, or space and its transfer to another object, substance, or space. Removal of heat lowers the temperature and may be achieved by use of ice, snow, chilled water or mechanical refrigeration.

There are four stages of the refrigeration unit, and they are

- Compressor
- Condensor
- Expansion
- Evaporator

Compressor

The compressor is widely measured the engine of the refrigeration cycle; it consumes the most power out of the HVAC system's components and strengths the refrigerant through the system. In the process of being compressed the cool, gaseous refrigerant is curved to a very hot and high-pressure vapor. After compression, the refrigerant moves to the next component in the refrigeration cycle: the condenser.

Condenser

The condenser's job is to cool the refrigerant so that it goes from a gas into a liquid, or condenses. This occurs when warm outdoor air is blown across the condenser coil that is filled with hot, gaseous refrigerant. This allows heat to transfer from the refrigerant to the cooler outdoor air, where the excess heat is disallowed to the atmosphere. The condenser coils wind through the condenser to exploit the surface area of the piping, and effectively, the heat transfers to the air. The refrigerant turns from a vapor into a hot liquid due to the high pressure and decrease in temperature.

Expansion valve

The refrigerant is now impending the expansion device as a hot, high-pressure liquid. The expansion device is answerable for quickly driving the pressure of the refrigerant down so it can boil (evaporate) more easily in the evaporator — and that's it! The expansion device has one sole purpose: to reduce refrigerant pressure. Because the pressure drops so quickly at the expansion device, the refrigerant turns into a combination of a cold liquid and vapor.

Evaporator

Now that the refrigerant is a cold mix of liquid and gas (vapor), it starts to move through the evaporator. The evaporator is responsible for cooling the air going to the space by boiling (evaporating) the refrigerant rolling through it. This occurs when warm air is blown across the evaporator as cold refrigerant moves through the evaporator coil. Heat transfers from the air to the refrigerant, which cools the air straight before it is vented to the space. Like the condenser coil, the evaporator coil also winds through the evaporator to maximize heat transfer from the refrigerant to the air. The low-pressure liquid refrigerant is effortlessly boiled by the warm air blown across the evaporator and heads back to the compressor as a cool gas/vapor.

Working principle

- The project consists of cold room structure which is made up of mild steel.
- The cold storage is sealed by the pith of coconut fibre.
- The refrigeration unit helps to maintain the low temperature inside the cold room.

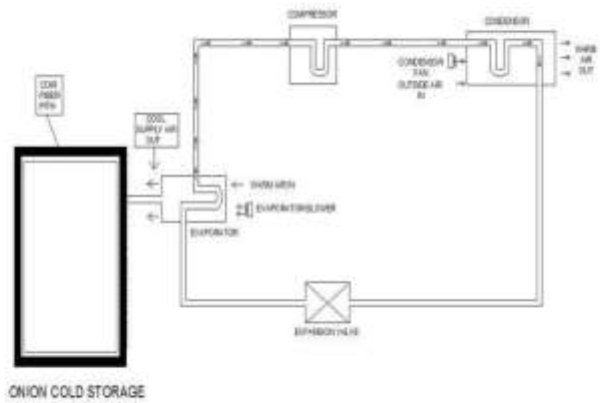

Fig.2.2. 2-D of a Onion Cold Storage System

III. DESIGN PROCEDURE

A. Crate Sizing

Design of thousand kilograms of onion cold storage depends upon the crate size and capacity. The crate size 0.6 × 0.3 ×0.25 m of each about 35kg were used. Twelve crates were put in a single layer, and up to three layers were stacked and we can add more crates also. The size of the crate and its stacking inside the storage are shown in Fig 2.1. The storage structure should be within 2 meters for service and fast handling.

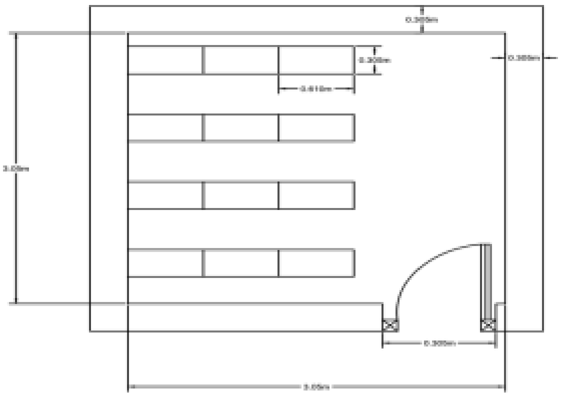

Fig.3.1 Sizing and Stacking of crates

B. Heat Load Calculation

From several sources, a building or space gains heat. Heat is created by inside inhabitants, machines, products, lightning and through opening and closing of door. Hence, summing up of all parameters gives the total heat load calculation.

a) Heat load from the Product $Q_{product}$

$= mC_{p\,above\,freezing}dt$

$=[1\times10^3\times3.88\times(15\text{-}0)]$

$= 58200$ kJ

$= \frac{58200}{24\times3600} = 0.674$ kW

b) Heat load by respiration Q_{resp}

The storage requirements and properties of the perishable products are given in the table 2.1 obtained from ASHRAE STANDARDS.

Table -1: Properties of Onion

Product	Storage temperature °C	Relative humidity %	Storage life	Heat of respiration J/kg	Specific heating above freezing (kJ/Kg.K)	Specific heating above freezing (kJ/Kg.K)
Onion	0-2	75	9 mon	728-1144 J/kg per 24 hours	3.78	1.94

$= 0.674 \times 1\times10^3$

$= 674$ kJ

$= \frac{674}{24\times3600} = 0.0078$ kW

c) Heat Load due to air occupied in the cold room

$Q_{resp} = m_{air}C_{pair}dT$

$= 1.22 \times 27 \times1.005 \times(35\text{-}0)$

$= 1158.6$ kJ

$= \frac{1158.6}{24\times3600} = 0.0134$ kW

d) Heat through Walls Q_{walls} = 4 walls+Ceiling+Floor

Q = Heat transfer through conduction= $KA\frac{dt}{L}$

Wall = 1 feet thickness = 0.305m

Area = LxB=3x3=9 m^2

$Q_{walls} = \frac{0.5 \times 8 \times(40-0)}{0.2286} = 0.059$ kW

For 4 side = 4x 0.059

= 0.236 kW

For ceiling $= \frac{T_1-T_2}{\left(\frac{L_1}{KA}+\frac{L_2}{KA}\right)+\frac{L_3}{KA}}$

Thickness of GI = 0.5mm

Thickness of air gap = 60mm

Thickness of coir peat =160mm

Thermal conductivity of GI = 0.02998W/mK

Thermal conductivity of air gap. = 0.024W/mK

Thermal conductivity of coir peat = 0.048W/mK

$= \frac{313-273}{\left(\frac{0.305}{0.02998\times9}+\frac{0.305}{0.024\times9}+\frac{0.305}{0.048\times9}\right)} = 0.236$kW

For Flooring (12 inch concrete)$= \frac{1.75 \times 4.84 \times(303-273)}{0.3048}$

= 1.0526 kW

Heat through Walls Q_{walls} =4walls+Ceiling+Floor

= 0.236 +1.0526+0.83

= 0.9 kW

e) Heat through equipment's Q_{equip}

= 2lights(each 20W)+ Evaporator fan motor

= 40 W+3 fan(200 W)

= No of lamp (or) fan x Time(hrs) x Watt 560 W

Q_{equip} = (2 x14x20)+(3x14x200) =8.96 kW

f) Heat through Persons Q_{person}

= 4-person x 750 x0.00029 = 0.87 W

g) Heat through Infiltrated air $Q_{infl\,air}$

Air load:

Volume of air = Total volume – Total volume of product

$= 3 - 1.26 = 1.74\ m^3$

Density of air = $\frac{P}{RT}$ = 1.117 kg/m^3

Mass of air = 1.117 x 1.74

= 1.94 kg of air

Q_{air} = $m\ C_P\ (OT)$

= 1x 1.94 x (40 – 0)

= 0.032kW

h) Heat through Door opening Q_{door}

= room volume X air changes per hour X air density X dT

= 27 x 0.06 x 1.22x (35-0)

= 0.064 kW

Total heat load calculation

= 0.674+0.0078+0.0134+0.9+8.96+0.87+0.032+0.064

= 11.152kW = 3.17 TR

Miscellaneous load = 10 to 30%

Miscellaneous load = 3.17 X 0.2 = 0.6 TR

So, the total heat load of the refrigerator is 4 TR were calculated.

C. On Grid Solar Roof Top System

On-grid systems send excess power generated to the utility grid when you are overproducing. These are the most cost-effective and simplest systems to install. It simply means that the entire system operates on a battery space.

Fig 3.1 On-Grid solar system

PVsyst:

PVsyst is a design software which contributes an array/system configuration, that permits us to demeanor a preliminary simulation.

The system design is grounded on a quick and simple procedure:

- state the desired power or available area
- select the PV module from the internal database
- select the inverter from the internal database

Grid-Connected System: Simulation parameters

Project :	New Project			
Geographical Site		Dindigal	Country	India
Situation	Latitude	10.36° N	Longitude	77.97° E
Time defined as	Legal Time	Time zone UT+5.5	Altitude	258 m
	Albedo	0.20		
Meteo data:	Dindigal	NASA-SSE satellite data, 1983-2005 - Synthetic		
Simulation variant :	New simulation variant			
	Simulation date	16/10/20 00h41		
Simulation parameters	System type	No 3D scene defined		
Collector Plane Orientation	Tilt	30°	Azimuth	0°
Models used	Transposition	Perez	Diffuse	Perez, Meteonorm
Horizon	Free Horizon			
Near Shadings	No Shadings			
PV Array Characteristics				
PV module Si-poly	Model	TP 325L BZp		
Original PVsyst database	Manufacturer	Tata Power Solar System		
Number of PV modules	In series	6 modules	In parallel	1 strings
Total number of PV modules	Nb. modules	6	Unit Nom. Power	325 Wp
Array global power	Nominal (STC)	1950 Wp	At operating cond.	1741 Wp (50°C)
Array operating characteristics (50°C)	U mpp	200 V	I mpp	8.7 A
Total area	Module area	11.6 m²	Cell area	10.5 m²

Fig 3.2 PVSYST Result for Grid-Connected System

For the above power consumption of 11.152 kW and location (Tamilnadu), number of PV modules(6 modules), unit normal power(325 Wp) for each module and total area(11.6 m2) are simulated.

Using solar

Power consumption (kW)	= 11.15 kW
Hours of use per day	= 7 hr/day
1kWh cost	= Rs 4.6
Electricity cost per day	= Rs 359
Electricity cost per month	= Rs 10,770

Grid

Hours of use per day	= 17 hr/day
1kWh cost	= Rs 4.6
Electricity cost per day	= Rs 1029
Electricity cost per month	= Rs 30,871

Total number of PV Module	= 6 no's
Cost of 325Wp module	= Rs 20,000
Total cost of 10 module	= Rs 1,20,000
MPPT converter	= Rs 65,000
Total charges = 1,20,000 + 65,000	= 2,85,000

Payback period:-

Electricity cost per day = Rs 359

$$\frac{2,85,000}{359} = 794 \text{ days}$$

Payback period = 2 year 1 mon

A lot of financial decisions are taken basis the simulation report which is given as an output by the software.

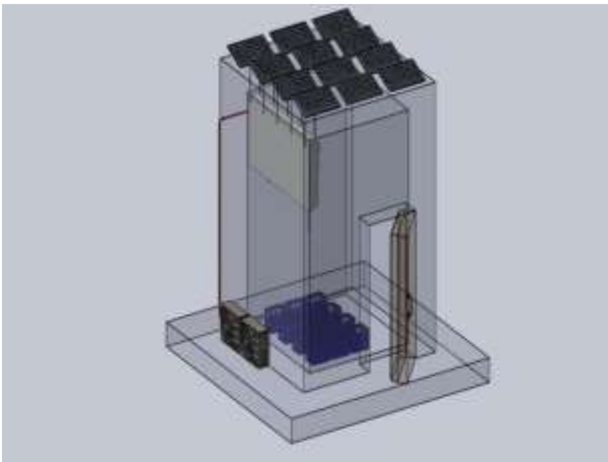

Fig 3.3 3D-Modelling of Cold Room(Transparent view)

Above fig 3.3 represents the 3D modelling of cold room withsolar modules at the roof top system. A cold storage unit has to be designed keeping in mind, several parameters and above stated design considerations. Erroneous design of any of the parameters stated, would result in serious issues like cost inflation, less efficiency/ COP of the system, wastage of power etc. The climatic conditions in which the cold storage is to function also plays a vital role in the selection of the material for the components and their design. In the existing review, all the important design considerations of a cold storage unit are compiled.

IV. CONCLUSION

The Farmers nowadays store onions in normal ambient conditions, which intend to lot more number of spoilage losses. This approach is advantageous to farmers because it acknowledges their problems and requirement for farmers. Making an accurate estimate of a cold store's refrigeration requirement takes a lot of practice, but it can only be achievedby a trained individual. The equation above isn't perfect, but it aids two purposes. It enables the reader to perform a similar calculation for his own store and obtain an estimate of the necessary refrigeration. It also lets the reader to appreciate the number of factors must be considered when calculating the heat load and also gives him some sense of their relative importance.

The future work of the project shall be extended to,

a) To model and simulate coconut fibre insulated wallusing steady state analysis (CFD).

b) The experimental evaluation of the coir peat insulted cold room could be carried out with the experimental values.

c) To analyze flow pattern and temperature distribution of the cold room using computational fluid dynamics (CFD).

d) To differentiate the losses and temperature distribution between normal ambient and cold storage conditions of onion

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