DESIGN OF COLD STORAGE

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Abstract - *This research paper gives overview of cold storage, its history, how it works, advantages and disadvantages, and its implementation. Cold storage is an important technology which is basically used for maintaining the quality of the produce and avoid the deterioration of the same. Nowadays, cold storage is gaining importance because of its positive result of avoiding spoilage of harvested produce. This paper focuses on the compact design of the cold storage which will be helpful for the farmers on small scale. It's basically designed for the formers who can't afford initial investment and wants to gain large profit from it. Cold storage consist of direct evaporative cooling system and supplemental refrigeration is air conditioning unit.*

Key Words: Insulation, direct evaporative cooling system, air conditioning unit.

1. INTRODUCTION

Harvested fruits and vegetables are living organisms and they maintain many of the biochemical reactions and physiological systems they operated when attached to the growing plant. They respire by absorbing oxygen and emitting carbon dioxide and heat plus they lose water (as this can no longer be replaced from the growing plant). The harvested produce relies on its own sources of energy and water to survive until its final consumption.

Different types of fresh produce have different abilities to survive and maintain their quality. Some types of produce have very short storage lives because they have high metabolic rates and high rates of water loss and must be kept under cool, humid conditions whereas other types of produce with low metabolic rates and low rates of water loss can be stored for long periods of time without the need for cool storage. Knowing the characteristics of the living produce can assist with decisions about managing storage and minimizing deterioration prior to consumption.

1.1 OBJECTIVE OF INVENTION

Local food systems can contribute to socially, economically, and ecologically beneficial food production for local communities. In order to deliver quality produce to the consumer, local food systems must utilize rapid cooling and cold storage technology. In the past thirty years, the number of local farms are increased, thus there is need for energy efficient cold storage units. Cold storage is essential for vegetable farmers to preserve produce quality and extend the revenue period.

1.2 BACKGROUND OF INVENTION

Food preservation is one form or another is being practiced from ancient times. Food preservation permeated every culture at nearly every moment in time. Food by its nature begins to spoil the moment it is harvested. Early farmers no longer had to consume or harvest immediately, but could preserve some for later use.

Famous preservation technique known to our ancestors was pickling, which is a technique for preserving food in vinegar (or other acid). Pickling may have originated when food was placed in wine or beer to preserve it, since both have a low pH. Containers were made of glass or stoneware, since the metal from pots can be dissolved by vinegar. Early cultures also used salt to help desiccate foods. Salting was common and even culinary by choosing raw salts from different sources (rock salt, sea salt, spiced salt, etc.). However, this process allowed food storage for only few days or week.

Canning is the process in which foods are placed in jars or cans and heated to a temperature that destroys microorganisms and inactivates enzymes. This heating and further cooling creates a vacuum seal. The vacuum seal prevents microorganisms from re-contaminating the jar food.

The techniques mentioned above were known from ancient times. The exact moment when these activities became common is unknown. However, as humans stepped into modern era and science and technology gained pace they began to question the science behind these ancient techniques. In America, estates had icehouses built to store ice and food on ice. Soon the "icehouse" became an "icebox". In the 1800's mechanical refrigeration was invented and was quickly put to use.

1.3 NECESSITY OF COLD STORAGE

Basically cold storage is used to increase the shelf life of produce as well as its supply. The freshness, palatability and nutritive value may be altered with time delay and therefore perishable foods can be preserved to prevent spoilage and made to be available throughout the year.

Once a crop is harvested, it is almost impossible to improve its quality. Proper storage conditions- temperature and humidity-are needed to lengthen storage life and maintain quality once the crop has been cooled to the optimum storage temperature. Fresh fruits and vegetables need low temperatures (32 to 55°F) and high relative humidities (80 to 95 percent) to lower respiration and to slow metabolic and transpiration rates.

2. FOOD PRESERVATION TECHNOLOGY

Food preservation is to prevent the growth of bacteria, fungi (such as yeasts), or other micro-organisms, as well as slowing the oxidation of fats that cause rancidity. Food preservation may also include processes that inhibit visual deterioration, such as the enzymatic browning reaction in apples after they are cut during food preparation.

All food preservation methods are based upon the general principle of preventing or retarding the causes of spoilage-microbial decomposition, enzymatic and non-enzymatic chemical reactions and damage from mechanical causes insects and rodents etc.

There are two types of preservation methods used:

Temporary preservation: In this method growth of microorganisms is only retarded or inhibited for short time.

Permanent preservation: In this method the growth of spoilage microorganisms are completely destroyed by different means.

3. DESIGN OF COLD STORAGE

3.1. Floor plan design

Small rooms are better for storage of fruits and vegetables due to the following reasons:
1. Different products require different temperatures and humidity's.
2. Some products are incompatible.
3. Ethylene producing products need to be vented regularly (other than short term storage).
4. Fruit and vegetable storage rooms require periodic cleaning, small rooms offer more flexibility and can be more energy efficient.

3.2. Insulated Panels

Use polyurethane insulated panels for cold storage facilities.

- 6 mm - 10 C and above
- 8 mm - 4 C to 10 C
- 10 mm - -4 C to 4 C

3.3. Total heat generated

The total amount of heat the cold storage must remove which enters via:

1) Conduction through the walls,

2) Respiration from the fruits,

3) Latent field heat from warm fruits ,

4) Service load generated from lights, fans and people coming in and out of the unit.

3.4. Relative humidity

Transpiration rates (water loss from produce) are determined by the moisture content of the air, which is usually expressed as relative humidity. At high relative humidity, produce maintains salable weight, appearance, nutritional quality and flavor, while wilting, softening and juiciness are reduced. Low relative humidity increase transpiration rates. A hygrometer or a sling psychrometer should be used to monitor humidity. Control can be achieved by a variety of methods:

1. Operating a humidifier in the storage area.

2. Regulating air movement and ventilation in relation to storage room load.

3. Maintaining refrigeration coil temperature within 2°F of the storage room air temperature.

4. Wetting the storage room floor.

3.5. Temperature

Respiration and metabolic rates are directly related to room temperatures within a given range. The higher the rate of respiration, the faster the produce deteriorates. Lower temperatures slow respiration rates and the ripening and senescence processes, which prolongs the storage life of fruits and vegetables. Low temperatures also slow the growth of pathogenic fungi which cause spoilage of fruits and vegetables in storage.

4. SYSTEMS USED

Design selected for system is direct evaporative cooling system and supplemental refrigeration is air conditioning unit.

4.1 DIRECT EVAPORATIVE COOLING SYSTEM

Direct evaporative cooling (open circuit) is used to lower the temperature and increase the humidity of air by using latent heat of evaporation, changing liquid water to water vapor. In this process, the energy in the air does not change. Warm dry air is changed to cool moist air. The heat of the outside air is used to evaporate water. The RH increases to 70 to 90% which reduces the cooling effect of human perspiration. The moist air has to be continually released to outside or else the air becomes saturated and evaporation stops.

A mechanical direct evaporative cooler unit uses a fan to draw air through a wetted membrane, or pad, which provides a large surface area for the evaporation of water into the air. Water is sprayed at the top of the pad so it can drip down into the membrane and continually keep the membrane saturated. Any excess water that drips out from the bottom of the membrane is collected in a pan and recirculated to the top. Single-stage direct evaporative coolers are typically small in size as they only consist of the membrane, water pump, and centrifugal fan. The mineral content of the municipal water supply will cause scaling on the membrane, which will lead to clogging over the life of the membrane. Depending on this mineral content and the evaporation rate, regular cleaning and maintenance is required to ensure optimal performance. Generally, supply air from the single-stage evaporative cooler will need to be exhausted directly (one-through flow) because the high humidity of the supply air

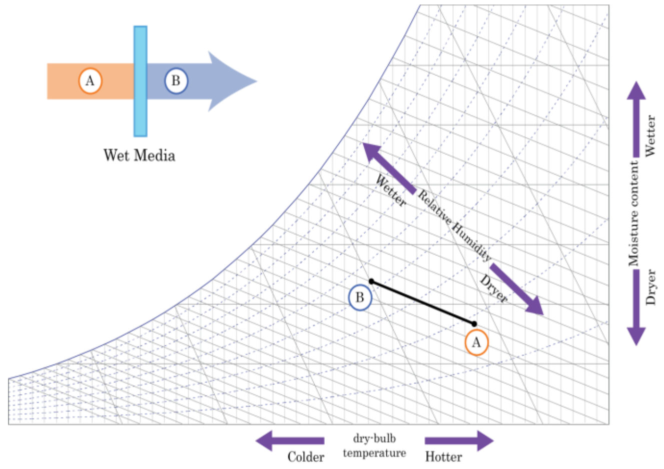

FIGURE 1. Psychrometric chart that shows relation between humidity and temperature

4.2 Mechanical systems

Apart from fans used in mechanical evaporative cooling, pumps are the only other piece of mechanical equipment required for the evaporative cooling process. Pumps can be used for either recirculating the water to the wet pad. Pump specifications will vary depending on evaporation rates and pad area.

For direct evaporative cooling, the direct saturation efficiency, measures in what extent the temperature of the air leaving the direct evaporative cooler is close to the wet-bulb temperature of the entering air.

4.2 AIR CONDITIONING UNIT

Air conditioning is the process of removing heat and moisture from the interior of an occupied space. Air conditioning can be used in both domestic and commercial environments. This process is most commonly used to achieve a more comfortable interior environment.

Air conditioners often use a fan to distribute the conditioned air to an occupied space to improve thermal comfort and indoor air quality. Electric refrigerant-based AC units range from small units that can cool a small room, to massive units installed on the roof that can cool an entire building. Cooling is achieved through refrigeration cycle, but sometimes evaporation or free cooling is used.

Air conditioning can refer to any form of technology that modifies the condition of air (heating, cooling, de-humidification, cleaning, ventilation, or air movement). In common usage, though, "air conditioning" refers to systems which cool air.

5. CALCULATIONS

Dimensions,

L = 6m

B = 5m

H= 4m

Conditions :

Ambient air = 30^0c at 50% RH

Internal air = 10^0c at 95% RH

Insulation =polyurethane (0.28 W/m^2K)

Ground temperature = 10^0c

1) Transmission load,
$Q = [U * A * (T_0 - T_I) * 24]/1000$

Opposite two walls will have same area, therefore

2 walls : 6 * 4 + 6* 4 = 24 +24 = 48 m^2

2 walls : 5 * 4 + 5* 4 = 20+ 20 =40 m^2

Roof : 6 * 5 = 30 m^2

Floor : 6 * 5 = 30 m^2

I. Walls and roof,
$Q = [0.28 * 118 * (30 - 10)*24]/1000$

Q = 15.8592 KW/ day

II. Floor,
$Q = [0.28 * 30 * (10 - 10) * 24*3600]/1000$

Q = 0

2) Product load,
$Q = m * C_P * (T_0 - T_I) / 3600$

$Q = 15000 * 3.411 * (30 - 10) / 3600$

Q = 284.25 KW/day

3) Respiration load,

Q = m * respiration rate / 3600

Q = 15,000 * 2 / 3600

Q = 8.33 KW/day

4) Internal heat load,
Light =

Q = lamps * time * watts / 1000

Q = 3 * 4 * 12 / 1000

Q = 0.144 KW/ day

People =

Q = people * time * heat / 1000

Q = 2 * 4 * 270 / 1000

Q = 2.16 KW/ day

5) Equipment load,
Fan motors =

Q = fan * time * wattage / 1000

Q = 2 * 24 * 600/ 1000

Q = 28.8 KW/ day

6) Total heat load

Q = 339.5432 KW/ day

7) First day rating of components,

Rating of air conditioning unit = 5.27 * 4

= 21.08 KW/ day

Rating of direct Evaporative cooling system = Total head load / working time

= (339.5432 – 21.08) / 24

= 13.2694 KW / day

Rating of the components will change after removal of product load, therefore

Rating of air conditioning unit = 5.27 * 1

= 5.27 KW/ day

Rating of direct Evaporative cooling system = Total head load / working time

= (339.5432 - 284.25 – 5.27) / 24

= 2.0843 KW / day

6. CONCLUSIONS

India is the fruit and vegetable basket of the world and most of the produce goes waste due to lack of storage facilities. Therefore, this concept is cost effective for the farmers on small scale to gain better quality produce. Two fans are operated (one in air conditioning unit and one in evaporative cooling system) so electricity consumption is also less as well as space required to build the room is also less. Use of direct evaporative cooling system will lower the air temperature surrounding the produce as well as increases the moisture content of the air. This avoids the drying of the produce, therefore extends the shelf life.

7. REFERENCES

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