Cooling Load Calculation for Cold Storage Using MATLAB

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ABSTRACT

Many Agricultural commodities, apples in particular are being kept in commercial cold storage. since the design parameter are not will defined and the problems associated with these cold storage are also not duly addressed in any farm for this reason a cold storage a batter storage facility and to promote the living standard of people . This Thesis deals with different aspects of designing of cold storage for 172 tons using MATLAB 2010 analysis. The maintenance of cold storage has also been highlighted to overcome the problem generally encountered in running a cold storage.

Keywords: - Sensible Heat Factor (S.H.F), Outside air sensible Heat (O.A.S.H), Room Sensible Heat Factor (R.S.H.F)

Introduction

1 Food Preservation

1.1 Definition:-

Food preservation is the process of treating and handling food in way preservation its value as food. The main effort is to stop or greatly slow down spoilage to prevent food borne illness (e.g. salting, cooling, cooking).

Preservation usually involves preventing the growth of bacteria, fungi and other microorganisms, as well as retarding the oxidation of fats which cause rancidity.

1.2 Various Techniques of Food Preservation:-

Because food is so important to survival, food preservation is one the oldest technologies used by human being. In this article we’ll look at all of the different preservation techniques commonly used today, including:

Table 1.2 Various Techniques of Food Preservation

S.No.	Techniques
1	Refrigeration and freezing
2	Canning
3	Irradiation
4	Dehydration
5	Freeze-drying
6	Salting
7	Pickling
8	Pasteurizing
9	Fermentation
10	Carbonation

The following are the general methods of food preservation:

- application of heat, such as canning and preserving, pasteurization, evaporation, sun-drying, dehydration and smoking,
- application of cold, as ill cold storage, refrigeration and freezing,

- the use of chemical substances such as salt, sugar, vinegar, benzoic and lactic acids,
- fermentation, examples being acetic, lactic, alcoholic, etc.,
- such mechanical means as vacuum, filtration and clarification processes, devices or agents for preventing chemical deterioration or bacteriological spoilage (the use of oil, paraffin and water glass are included here),
- Combinations of two or more of the above.

Food preservation has become an increasingly important component of the food industry as fewer people eat foods produced on their own lands, and as consumers expect to be able to purchase and consume foods that are out of season.

Food spoilage can be attributed to one of two major causes:

- the attack by pathogens (disease-causing microorganisms) such as bacteria and molds.
- Oxidation that causes the destruction of essential biochemical compounds and/or the destruction of plant and animal cells.

The various food preserving methods are all designed to reduce or eliminate one or the other (or both) of these causative

The basic idea behind all forms of food preservation is either:

1 To slow down the activity of disease-causing bacteria.

2 To kill the bacteria altogether.

In certain cause. A preservation technique may also destroy enzymes naturally found in a food that cause it to spoil or discolor quickly. An enzyme is a special protein that acts as a catalyst for a chemical reaction, and enzymes are fairly fragile. By increasing the temperature of food to about 150^0F (66^0C), enzymes are destroyed.

A food that is sterile contains no bacteria. Unless sterilized and sealed, all food contains bacteria. For example, bacteria naturally living in milk will in two or three hours if the milk is left out on the kitchen counter at room temperature. By putting the milk in the refrigerator you don't eliminate the bacteria already there, but you do slow the bacteria enough that the milk will stay fresh for a week or two. Let's look at food preservation by using refrigeration and freezing i.e. cold storing in detail.

1.3 Definitions of Refrigeration and Air Conditioning:-

1.3.1 Refrigeration:-

Literally refrigeration stands for the production of cool confinement with respect to surrounding. A few definitions of some authors are listed below.

It may be defined as the artificial with draw of heat, producing in a substance or within a space at a temperature lower than that which would exist under that natural influence of surrounding. According to ASHRAE, it is defined as the science of providing and maintaining temperature below that of surrounding.

1.3.2 Air Conditioning:-

In general, air conditioning is defined as the simultaneous control of temperature humidity and cleanliness and air motion.

Air conditioning is subdivided to comfort and industrial air conditioning. This is use human comfort, production shop laboratories, textiles, manufacture of material and precision devices, printing, photographic product, cold storage, pharmacy, computer etc.

1.4 Brief History of Refrigeration:-

As for back as history record the activity of the human race, we find that one of the greatest concerns of mankind has the preservation of foods. Refrigeration as an art had been known for thousand of year, in an ancient's Chinese collection of poems, Shiching, there is reference to the use ice cellars in 1000 B.C. The Indian Egyptians and Estonians chilled water and even produced ice by placing water in shallow porous clay vessels , then leaving this overnight in holes in the ground.

The history of mechanical refrigeration dates to 1790, during which a machine was developed, a hand operated refrigeration machine using highly volatile like ether as working fluid in 1834. Then in 1851 came Gorrie's air refrigeration machine and in 1856 Linde developed a machine working on Ammonia.

The pace development was slow in the beginning when steam engines were the only prime movers to run the compressor, with the advent of electric motor and consequently higher speed of compressor in the early 20^{th} century , the scope of application of refrigeration winded. During the civil war there was an acute shortage of supply of natural ice from the north. Hence, Ferdinand Carrey of the U.S.A. developed the vapoure – absorption system refrigeration system using ammonia and water.

The possible use of east heat or solar energy in case of vapoure absorption and thermoelectric system has led to developed of several commercial unit days especially due to the like hood of future energy crisis, the world is going to face.

HEAT GAIN AND LOAD

CALCULATIONS

2.1 Introduction:-

The refrigeration engineer may encounter a wide variety of applications in his practice. In order to determine the proper equipment to use in each case he must first calculate the load and study its characteristics.

Many of the fundamentals of heat transmissions are applied in load calculations. In most cases heat transfer by condensation occurs. Or in many instances heat transfer by convection or by radiation, or by both takes place.

The components of the heat gain in an air cooler space are of two types, sensible heat and latent heat. It is important to differentiate between the two since the ratio of the total quantity of the one to that of the other affects the determination of the proper balance of equipment required. Keeping this in mind. It is necessary for the refrigerating engineers to about the heat sources and their nature before taking up the job of designing a cold storage.

2.2 Component of Cooling Load:-

The System has taken care of two types of loads.

(A) Sensible heat load

(B) Latent heat load

(A) Sensible Heat Load :-

The sources which contribute to sensible heat load are listed below:-

(I) Fabric Heat Gain:-

Heat flows through exterior walls, ceilings, floors and doors due to release of solar heat absorbed by building structures and the temperature difference between ambient and room.

(II) Solar Loads through Transparent Surfaces :-

Heat gain from the sun which is transmitted through the glass.

(III) Occupancy Load:-

Heat received from the occupants.

(IV) Product Load:-

Product load from incoming goods.

(V) Equipment Load :-

Heat received from different equipments which are commonly used in buildings.

(VI) Infiltration :-

Heat received from in filtered air from outside through cracks in windows and doors through frequent door openings.

(VII) Lighting Load :-

Electric lights generate a sensible heat equal to the amount of electricity Consumed.

B. Latent Heat Load:-

The sources which contribute latent heat load are given below:-

(I). Infiltration: - Latent heat load from opening of doors and windows.

(II). Occupants load: - Latent heat load from occupants.

(III). Product load: - Latent heat load from cooling food and from stored materials.

(IV).Equipment load: - the latent heat produced on the function the Equipment performs, such as drying working etc.

2.3 Heat Leakage Variables:-

The five factors that affect the heat leakage are:-

- Time.
- Temperature difference.
- Thickness of the insulation.
- The kind of insulation.
- The external area of chamber.

2.4 Thermal Transmission:-

The heat transfer by conduction though walls and ceilings to the conditioned space is seldom steady even if the temperature in the conditioned space is maintained constant ; the rapid changes in the ambient temperature cause the unsteady state.

The general procedure to calculate heat gain or heat loss thermal transmission is to apply the equation. Arora C.P. [11]

$Q = UA (t_o - t_i)$……………………………2.1

Where
U = overall heat transfer coefficient W/m^2k
A = Surface area m^2
$t_o - t_i$ = outside – inside temperature difference K

The overall heat transfer coefficient is given by

$$\frac{1}{U} = \frac{1}{f_i} + \frac{x_1}{k_1} + \frac{x_2}{k_2} + \dots + \frac{1}{f_o} \dots\dots\dots 2.2$$

Where,

f_i = heat transfer coefficient on inner surface
f_o = heat transfer coefficient on outer surface
x/k= thermal resistance of material used for the construction of wall

2.5 Solar Loads:-

The process of solar heat gain for an opaque wall is illustrated schematically in fig4.1. A portion of the solar energy is reflected and the remainder is absorbed. Of the energy absorbed some is convicted and some radiated to the outside. The remainder of the absorbed energy is transmitted to the inside by conduction or temporarily stood.

The transmissivity τ of an opaque surface is zero. And thus for walls and roofs.

$\rho + a = 1$

Hence the solar energy entering. Arora C.P. [11]

$$Q_w = \frac{U_w I_t A}{H_o}$$

Where,
I_t = irradiation on exterior surface w/m
H_o = outside heat transfer coefficient w/m
ρ = reflectance
a = absorbance

If the transmission due to air temperature difference is included,

$$Q_w = \frac{U_w I_t A}{H_o} + U_w A(t_o - t_i)$$

$$Q_w = U_w A[(\frac{t_o + \alpha I t}{H_o}) - t_i]$$

It is apparent that if the first term in the brackets is replaced by an equivalent temperature t_e,

where,

$$t_e = \frac{t_o + \alpha I t}{H_o}$$

Hence,

$$Q_w = U_w A(t_e - t_i)$$

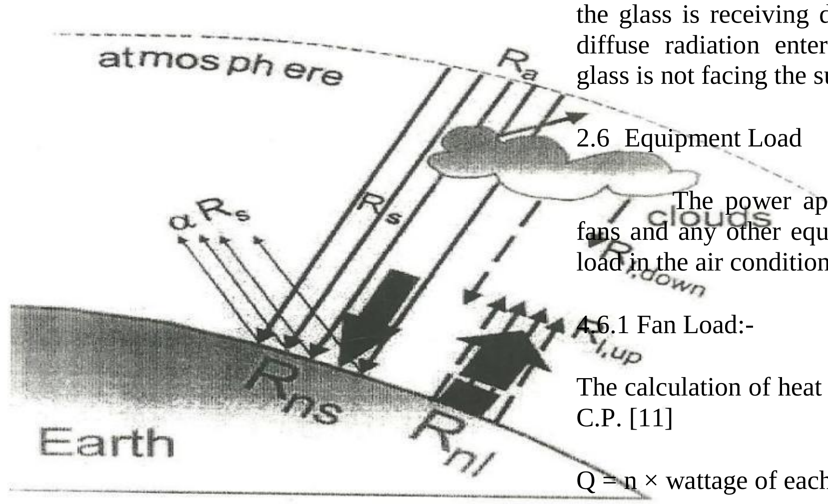

Fig 2.1 solar heat gain for an opaque wall

The equivalent temperature they called the sol- air temperature is the outdoor temperature increased by an amount to account for the solar radiation.

For opaque walls, however, the effect of thermal storage can be quite pronounced, and using the temperature difference (te – $t_{i)}$ may significantly overestimate the heat gain. To incorporate the effect of thermal storage an equivalent temperature difference, called the cooling load temperature difference (CLTD), has been developed for commonly used wall cross sections.

2.5.1 Periodic Heat Flow:-

The temperature of the walls of the buildings increase with the increase in the outside air temperature and the heart is stored in the wall as the wall has the considerable storage capacity. This stored energy is given up to the room in the evening.

4.5.2 Solar heat gain through glass :-

The heat gain if a space through glass comprise of:-

(i) All the transmitted radiations.
(ii) A part of the absorbed radiation that travels to the room, and
(iii) The heat transmitted due to the temperature difference between the outside and inside conditions.

The direct radiation enters the space only if the glass is receiving direct sunrays of the sun. The diffuse radiation enters and space even when the glass is not facing the sun.

2.6 Equipment Load

The power appliance such as light motors, fans and any other equipment of this type adds heat load in the air conditioned space.

4.6.1 Fan Load:-

The calculation of heat gain is done as follows. Arora C.P. [11]

Q = n × wattage of each fan …..…………2.4

Where,

n = number of fans

2.6.2 Lighting Load :-

Electric light generates a sensible heat equal to the amount of the electric power consumed.

The calculation of hat gain is done as follows. Arora C.P. [11]

Fluorescent Q= n × total watts × 1.25…………..…………………….2.5

Incandesce : Q= n× total watts…………………..…………………….2.6

2.7Product Load:-

The heat load added by the product to be stored is very important in the design of cold storage. The loads to be considered are of four types which are given below.

1. Chilling above freezing
2. Freezing
3. Cooling below freezing
4. Respiration heat

2.7.1 Chilling Above Freezing:-

Five factors must be known in order to design the product chilling load.

(1) The entering product temperature should be obtained, possible from the men in charge of the operation in space.

(2) The final temperature desired should be selected, usually from the table based on recent experiences.

(3) The maximum quantity of product that is to be chilled at any one time must be decided.

(4) The chilling time required for the kind and individual size of the product handled is fixed and can be obtained from the rest data available.

The specific heat of the product chilling load above freezing is given by Arora C.P. [11]

$$Q_{cl} = \frac{m.c(T_1 - T_2)}{\text{chailling time}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots 2.7$$

Where,

m = mass

c = specific heat of the product about freezing

T_1 = initial temperature of the product

T_2 = final temperature of the product

2.7.2 Freezing:-

Freezing load is given by Arora C.P. [11]

$$Q_f = \frac{mL}{\text{freezing time}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots 2.8$$

Where,

L = latent heat of freezing

2.7.3 Cooling below Freezing:-

Cooling load below freezing is given by Arora C.P. [11]

$$Q = \frac{mc(T_s - T_f)}{\text{cooling time}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots 2.9$$

Where,

c =specific heat of product below freezing.

T_s =storage temperature of the product.

T_f =freezing temperature of the product.

2.7.4 Respiration Heat :-

Fruits and Vegetable are still alive after harvesting and continue to undergo changes while in storage. The most important of these changes are product by respiration, a process during which oxygen for the air combine with carbohydrate in the plant tissue and the result in carbon-dioxide and heat. The heat released is called respiration heat and must be considered as a part of the product load.

The heat generated by the food is given by Arora C.P. [11]

Q = m × Heat evolved per kg of food per hour……..2.10

2.8 Infiltrations:-

Infiltration is the name given to the leakage of outside air through door openings and through crack and interstices around window and door into conditioned spaces. Even through the air inside is slightly pressurized, the leakage does take places which is principally due to following factor.

2.8.1 Stack Effect:-

Differences between temperature and humanities produces differences in the densities of air between the outside and insides of buildings. As a result, pressures a difference occurs causing flow of air know as chimney or stack effect. In the case of cold storage it can be neglected due to insulated walls.

2.8.2 Wind Action :-

The flow of air due to wind over a building creates regions in which the static pressure is higher or lower than the static pressure in the undisturbed air stream. The pressure is positive on the windward side resulting in the infiltration of air, and negative on the leeward side resulting in infiltration. In the case of cold storage it can be neglected due to absence of window.

2.8.3 Infiltration due to Door Openings :-

Infiltration due to door opening can be minimized in case of cold storage by the use of air curtain.

Air curtain -

It is a device which is fitted above the door. The function of the air curtain is to prevent the uncontrolled air filtration load during loading and unloading situations.

Safety factor -

Safety factor is strictly a factor of probable error in the estimation of the load. For this purpose, additional 5 percentage heat should be added the room sensible and room latent heat. Arora C.P. [11]

Result &Conclusion

3.1 Objective Achieve:-

Considering the annual demand of apple in Baster (Chhattisgarh) and nearby areas for 172 ton of apples.

The following salient feature has been obtained.

1. Inside Design Condition 0^0C DBT and 90% RH
2. Outside Design Condition 40^0C DBT and 28^0C WBT
3. Refrigeration capacity as obtained from manual calculation = 8.108TR Refrigeration capacity as obtained from Met Lab calculation = 8.109TR
4. Refrigeration capacity = 8TR
5. By comparing the Refrigeration capacity in both cases is same. Hence it is feasible and valid.
6. From Mat Lab programming if we keep same thickness of thermocole for wall, ceiling and floor. The Refrigeration capacity is 6.353TR≃6TR. It is indicate the economical aspects for energy saving

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