IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

THERMAL SYSTEM DESIGN OF A COLD STORAGE FOR 1500 METRIC TONNE POTATOS

Dr. Sharad Chaudhary*, Virendra Sharma
Asstt. Professor, Mechanical Department, Institute of Engineering & Technology DAVV- Indore, MP India
M.E. with specialization in Design & Thermal Engineering, IET DAVV Indore, India

ABSTRACT
The principal of refrigeration is method of successful storage of vegetable and fruits to maintain their flavour and freshness, for post harvest product deterioration start with time and temperature so it need to be maintain desirable temperature and relative humidity for post harvest product that is for potato. A cold storage design at village HARSODAN district Ujjain (m.p.) to give better facility for potato storage. This paper deal with all standard refrigeration principles and different aspect of design of cold storage and this design is hypothetically intended to serve as a guide for future fabrication and erection.
.**KEYWORDS**: refrigeration, refrigeration principle, heat load, refrigeration system design.

INTRODUCTION
Production of potato in India has increase in the last 50 years. Increase in production many time resulting in gluts at harvest, has led to several post-harvest problems and the major one is that of their proper storage. It has been seen that total of 90 per cent of potato crop of the India is harvested during January-February from the Indo-Gangetic plains, the states of, Haryana, UP, , Punjab, Bihar ,West Bengal, MP and Gujarat where the harvest is followed by rising temperatures of hot and dry summer and further by warm and humid rainy season. Since according to bio chemistry of potato, potato tubers contain about 80% water (1), under these conditions, When potato are harvested, they are cut-off from their source of water and nutrition and then they start to deteriorate, shrinkage, sprouting, attack by microorganisms, lose weight, texture, flavour, nutritive value and appeal. potato, a semi-perishable commodity and cannot be stored without refrigeration for more than 3-4 months due to very high losses So it store in refrigerated cold store at 2-4^{0}c and 90-95% relative humidity(2). Sprout growth, low evaporation, pests and minimum risk of disease of potato can be control by maintaining low temperature and high humidity. Required temperature, relative humidity and storage period for early crop, seed potato and table potato are given in table-1

Table-1 storage conditions of potato(2)

Fresh Potato	Temperature	Storage Period (months)	Relative Humidity
Early Crop	4 – 10°C	0 – 3	95%
Seed Potato	3°C	5 – 10	90 – 95%
Table Potato	4°C	5 – 10	90 – 95%

PRINCIPLES OF REFRIGERATION
Refrigeration is the process of removing heat from a substance under controlled conditions
The vapour compression refrigeration cycle has four components: evaporator, compressor, condenser, and expansion (or throttle) valve. The most widely used refrigeration cycle is the vapour-compression refrigeration cycle. In an ideal vapour-compression refrigeration cycle, the refrigerant enters the compressor as a saturated vapour and is cooled to the saturated liquid state in the condenser. It is then throttled to the evaporator pressure and vaporizes as it absorbs heat from the refrigerated space all the Processes of refrigeration employed in the cold room shown in fig [3]

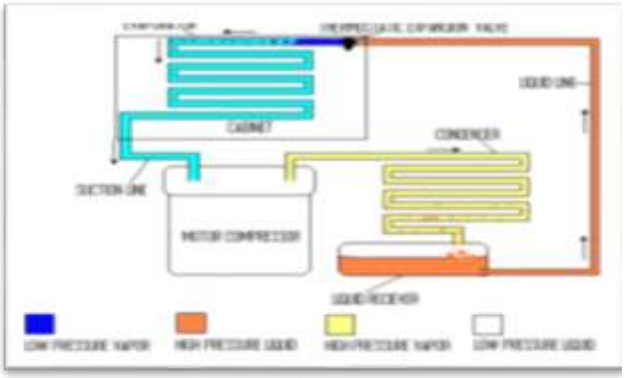

Figure 1: Processes of refrigeration employed in the cold room[4]

The ideal vapour compression cycle consists of four processes Shown in T-s and P-h diagram

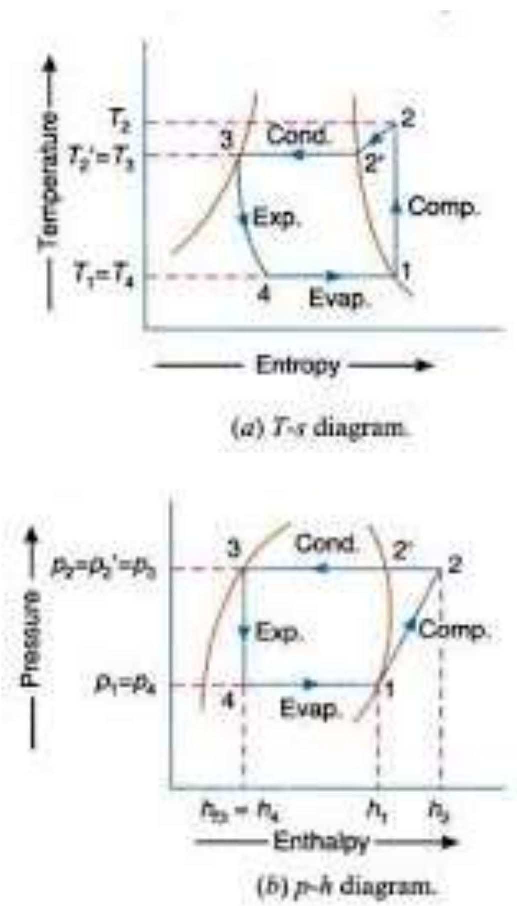

Figure 2 T-s and P-h diagram of ideal vapour compression cycle[3]

Table 2 process and their description[5]

Process	Process name	Process Description
1-2	Isentropic compression	Wc= h2 – h1
2-3	Constant pressure heat rejection in the condenser	Qc = h2 – h3
3-4	Throttling in an expansion valve	h3 = h4
4-1	Constant pressure heat addition in the evaporator	Qe = h1 – h4

Coefficient of Performance = refrigeration effect / work done

COP = (h1 – h4) / (h2 – h1)

DESIGN METHODOLOGY

Cold Storage Design Location

The project site which is under my study criteria named Tirupati cold storage is situated in village Harsodan, Distt. Ujjain (M.P.). Ujjain is located in the Malwa region of Madhya Pradesh in central India. The city is situated between 23° N and 75.78° E, with an average elevation of 491 meters .The storage capacity of cold store is 6ooo MT. having 4 chambers with individual storage capacity of 1500 MT.

Data collection

There are two type of data collection required

Basic Design Data- Basic design data is that data which give information of location of plant there capacity, atmospheric condition around cold storage plant, product temperature and there loading rate.

Commodity Storage Requirements data- Data regarding the product which is to be stored inside the cold store that has to maintain inside the cold store

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

Plant Layout and drawing of cold storage:

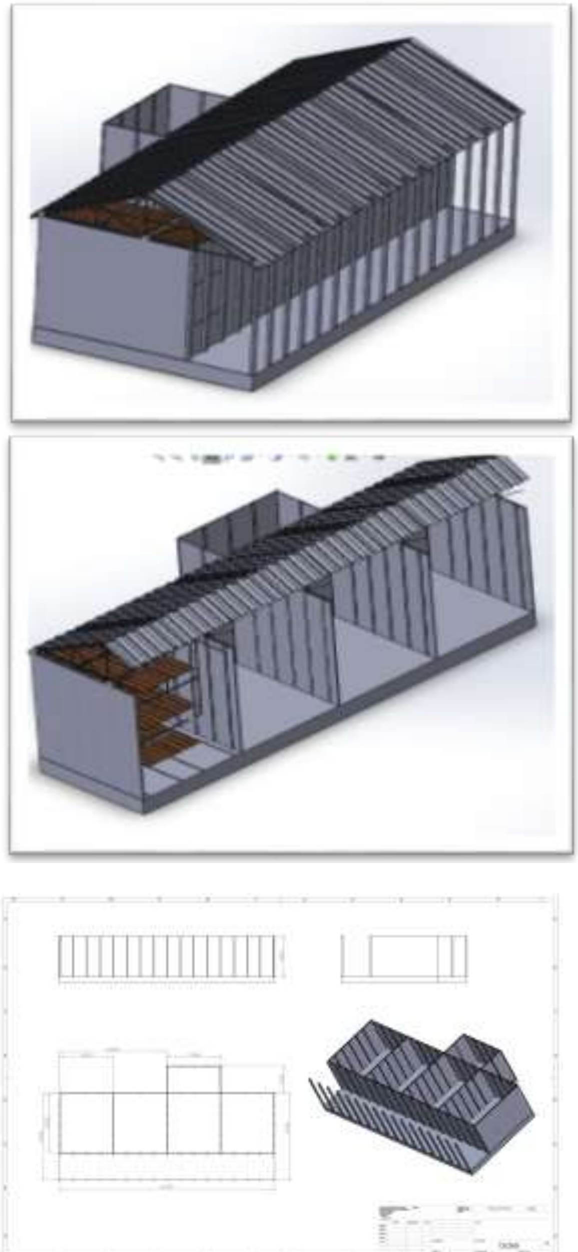

Figure: 3Plant layout and sectional view of cold storage

Heat Load Determination

The total heat load consists of the amount of heat to be removed from a cabinet during a certain period. It is dependent on two main factors: heat leakage or heat transfer load, and heat usage or service load, respectively.

Heat Leakage Load.

Heat leakage load or heat transfer load is the total amount of heat that leaks through the walls, windows, ceiling, and floor of the cabinet per unit of time(4)

Building transmission load.

The building transmission load is the total amount of heat that leaks through the walls, windows, ceiling, and floor of the refrigerated room per unit of time (usually kW)(4)

Building transmission load=(U)(A)(ΔT) (kJ/s).

Where A = the outer surface area of the building (m²);

U = the overall coefficient of transmission (W/ m²°C); and

ΔT = the temperature difference (°C).

Determination of the U factor

(1/U)=((1/hi)+(x1*/k1)+…….+(xn/kn)+(1/ho))*

Where hi=convection coefficient of inside wall, floor or ceiling.

ho=convection coefficient of outside wall, floor or ceiling.

Determination of hi and ho for constant wall temperature. (6)

$$h = \frac{k}{L}\left(0.825 + \frac{0.387Ra_L^{1/6}}{(1+(0.492/Pr^{9/16})^{8/27}}\right)^2 \quad (7)$$

Heat Usage Load

The heat usage or service load is the sum of the following heat loads per unit of time Cooling the commodity to cabinet temperature, Cooling of air changes, Removing respiration heat from potato, Removing heat released by electric lights, electric motors, and the like, and Removing heat given off by people entering and/or working in the cabinet, respectively. (4)

Air change heat load.

Air that enters a refrigerated space must be cooled. Air has weight and it also contains heat . When air enters the refrigerated space, heat must be removed

ACL=(V)(ACD)(ho-hi)(ρ)

Where ACL = Air change load due to door opening, infiltration and

Ventilation etc. (kW);

V = Volume of the cold room (m³);

h = Enthalpy of air (kJ/kg);

ρ = Density of air (kg/m³);

ACD = Air change per day, number of times; and Subscripts o and i denote out and in, respectively.(5)

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

Table 3Air changes table [8]

Room volume in cubic meter	1ooo	1500	2000	2500	3000
Number of air changes/24 hours	2.8	2.8	2.77	2.75	2.73

Product heat load

Any product which is warmer than the refrigerator is placed where it will lose heat until it cools to the refrigerator temperature. That heat is product heat load.[5]

Q= (M)(C)(ΔT)

Where Q= the quantity of heat in kW

M=mass of product in kg

C= the specific heat of potato above freezing kJ/kg K

ΔT = the temperature difference (°C)

Respiration load:

Fruits and vegetables are still alive after harvesting and continue to undergo changes while in storage .the more important of these change are produced by respiration, a process during which oxygen from the air combine with the carbohydrates in the plant tissue and results in the release of co2 and heat. The heat release called respiration heat. in such case heat gain is compute by the following equation.[5]

Q=(M) (respiration heat)

Where Q= the quantity of heat in kW

M=mass of product in kg

Respiration heat= 0.0325 kJ/kg hr[9]

Miscellaneous load:

The miscellaneous load consists primarily of the heat given off by lights and electric motor operating in the space and by people working in the space. The following calculations are made to determine the miscellaneous heat gain. [2]

Light: = (wattage) (number of hour) kW

Electric motors= (Factor) (horse power) (number of hours)

People= (heat equivalent/ person) (number of people) (number of hours)

Total Cooling Heat Load = Heat transmission through walls + Heat transmission through ceiling + Air change heat load + Product load + Respiration load + Human occupancy + Equipment load

Design of cold storage Mechanical system

Before designing of cold store first we select refrigeration system and refrigerant, which is simple vapour compression refrigeration system and ammonia (NH_3) after selecting refrigeration system and refrigerant select two saturated temperature first condenser temperature and second evaporator temperature. Hear condenser temperature depend on atmospheric temperature that is maximum temperature in summer and evaporator temperature depend on inside cold storage temperature so evaporator temperature maintain as much below that we have to maintain in side cold storage temperature. After selecting saturated temperatures prepare refrigeration cycle and Draw T-s and P-h diagram. Consider case of super heating at suction of compressor.

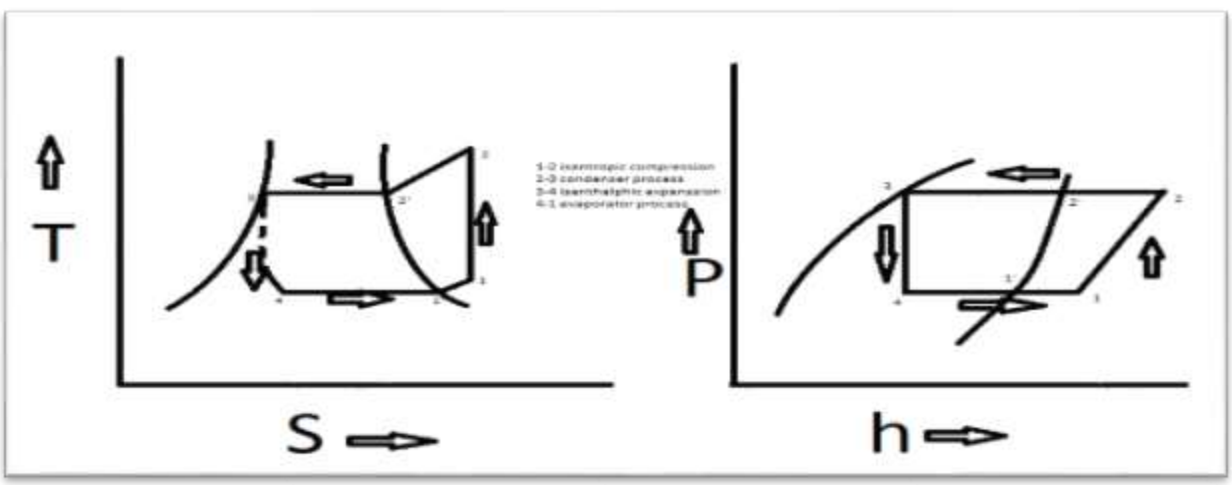

Figure 4 T-s and P-h diagram of vapour compression refrigeration cycle

Calculation procedure for calculation of COP, Mass flow rate and horse power needed to produce calculate heat load.
Calculate enthalpy at each stat ie h_1, h_2, h_3,h_4.
Calculate compressor work = (h2- h3)
Calculate refrigeration effect = (h1-h4)
Calculate condenser load = (h2 – h3)
Calculate cop of system =(refrigeration effect / compressor work)
horse power needed to produce calculate heat load
COP = (Total TR / Power)
calculation for mass flow needed for refrigeration effect
Tonne of refrigeration =m_r (h1 – h4) [9]

Design of compressor
Find At state no 1 specific volume vg1
Calculate Volumetric flow rate = $m_r \times$ vg1
Calculate actual volume flow rate corresponding to given volumetric efficiency
ηv = (actual volume flow rate / Theoretical volume flow rate)
Find the diameter and stroke length for a given rang of RPM and for number of cylinder and For given L/D ratio.
Actual volume flow rate = no of cylinder $\times(\pi/4)D^2\times L\times$RPS [9]

Design of condenser
Find total condenser load that is the total heat rejected at the condenser includes both the heat absorbed in evaporator and the energy equivalent of work of compressor.
Condenser load Qc = evaporator load + work of compressor
Calculate mass flow rate of water required for condenser load.
$Qc = m_w \times C_p \times (T_f - T_i)$
T_i = initial temperature of water.
T_f = final temperature of water after supply to condenser.
m_w = mass flow rate of water for given condenser load.
Cp= specific heat of water.
c) Convert mass flow rate of water in gpm (gallon per minute) per tube for a given no of tube.
d) From graph calculate the value of U (over all heat transfer coefficient) for scale factor .003

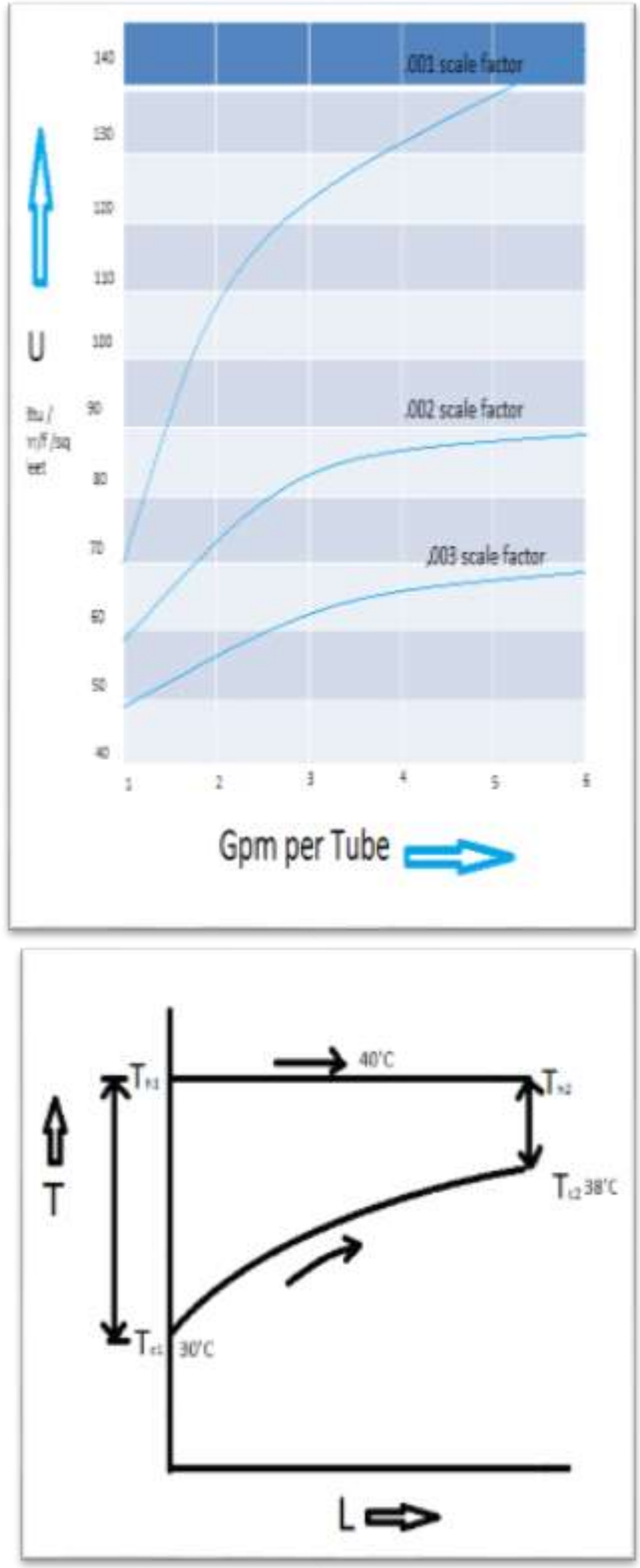

Figure 5 courtesy of acme industries and LMTD of Condenser(5)

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

Calculate surface area required for a given condenser heat load by LMTD (logarithmic mean temperature difference method)

$Q_c = U \times A \times \Theta_m$

Θ_m = ((th1-tc1) –(th2- tc2))/(ln(th1-tc1)/ (th2- tc2))

A =outside surface area of condenser

d = outside di of condenser tube.

l = length of tube per tube.

Find the length of tube for given number of pass and given diameter.[5]

Design of Throttling Device

Throttling device must be capable of expanding 143.096 m^3/hr and must operate in the pressure range of 2.263 bars to 15.55 bars.(2)

Design of Evaporator

As per technical standards committee on technical standard and protocol for cold chain (technical standard number NHB-CS-type 01-2010) in India suggest that minimum 50 CFM/MT of potato during loading and pull down period. so corresponding to storage capacity of potato calculate total CFM and for a given tonne of Refrigeration select an appropriate evaporator.[10]

DATA COLLECTION AND DATA ANALYSIS

Basic Design Data-

Plant location: village HARSODAN Distt. UJJAIN (M.P.)

Outside dry-bulb temp: +40°C (max.)

Outside wet-bulb temp: +30°C (max.

Product Temperature at the time of loading: 20 °C to 25 °C

Total Storage Capacity: 6000 Mt

No of Chambers & Capacity: 4 X 1500 Mt.

Chamber Size: 20.80 m x 16.625 m x 14.0 m (L xWx H)

Loading Rate: 4% to 5% of the total storage capacity / day (equally split into four chambers)

Cross section area for each wall and each chamber. Table 4

Table 4. Area of different wall

Wall	East wall	West wall	North wall	South wall
Area (m^2)	291.2	291.2	232.79	232

Commodity Storage Requirements data

Type of Commodities/Produce: potato

Air Circulation (CMH/MT of Produce): 50

Ventilation (Air Changes/Day): 1.5-3

CO 2 Range (PPM): 2000-4000

Max Storage period (months): 6-8

Daily loading rate (MT/day): 75

Cold Chamber Dry bulb (DB in °C): 2-4 degree centigrade

Cold Chamber RH (%): 95-98

Volumetric calculation of cold storage plant-

As a total volume of each chamber = (Length)×(Width)×(Hight)

Volume of chamber= (20.8)×(16.628)×(14)

Volume of chamber =4842.07 cubic meter

Volume of potato for 1500 Mt

Density = (mass/volume)

Volume= (1500000)/ (769)

Volume= 1950.5 cubic meter

The volume of potato for 1500Mt is 40% of total volume for 1500Mt and remaining 60% is for Handling, loading, unloading, air circulation.

Cooling load calculation*:*

There are four chamber of cold storage each having capacity of 1500 Mt. So load calculation is only for 1500 Mt. That will be same for remaining chamber.

Heat transmission through walls: -

Considering walls consisting of 2.54 cm thick plaster(x1)(K1-.123w/mk) at outer side then 22.86 cm thick brick(x2)(K2-1.31w/mk) then 2.54 cm thick plaster(x3)(K3-.123w/mk) at inner side and 5.08 cm thick PUF(x4)(K4-.023w/mk) as a insulation. For all east, west, north and south wall. (2)

Building transmission load Q = (U)× (A) ×(ΔT) (kJ/s).(6)

Determination of the U factor

(1/U)= ((1/hi)+(x1/*k1)+…….+(xn/kn)+(1/ho))*

Determination of hi and ho for constant wall temperature.

$$h = \frac{k}{L}\left(0.825 + \frac{0.387 Ra_L^{1/6}}{(1 + (0.492/Pr^{9/16})^{8/27}}\right)^2 \quad (7)$$

Calculation for ho : take all value corresponding to DBT i.e. 40 degree centigrade and calculate value of Pr and RaL number put in equation and calculate ho=2.245 W/m² k

Calculation for ho : take all value corresponding to DBT i.e. 3 degree centigrade and calculate value of Pr and RaL number put in equation and calculate hi hi=1.484 W/m² k

By calculating ho,hi calculate value of U.

Determination of the U factor

(1/U) = ((1/hi)+(x1/*k1)+…….+(xn/kn)+(1/ho))*

U=.255 w/m²k

Heat gain through east wall having area is 291.2 m²

Q=UA(To-Ti)

Q= (.255)(291.2)(40-2)

Q= 2.855 kW

Heat gain through west wall having area is 291.2 m²

Q=UA(To-Ti)

Q= (.255)(291.2)(40-2)

Q= 2.855 kW

Heat gain through north wall having area is 232.89 m²

Q=UA(To-Ti)

Q= (.255)(232.89)(40-2)

Q= 2.255 kW

Heat gain through south wall having area is 232.89 m²

Q=UA(To-Ti)

Q= (.255)(232.89)(40-2)

Q= 2.255 kW

Heat transmission through ceiling: -

Considering ceiling consisting of 3mm thick asbestos sheet(x1)(K1-2.7w/mk) and 10 cm thick thermacol (x2)(K2-.028w/mk).

So U for ceiling.

U= .28 W/m²k

Heat gain through ceiling having area is 320 m²

Q=UA(To-Ti)

Q= (.28)(320)(40-2)

Q= 3.4 kW

Air change heat load.

ACL = (V)(ACD)(ho-hi)(ρ)

V = 1950 (m³)

ρ= 1.12 (kg/m³);

ACD = 2.65/day

Subscripts o and i denote out and in, respectively.

Corresponding to To=40 degree centigrade and 50% RH value of ho=105kj/kg

Same as Ti= 2 degree centigrade and 95% RH value of hi=15kj/kg

ACL=6.0742kW

Product load:

Loading Rate: 4% to 5% of the total storage capacity / day (equally split into four chambers) so It take 20 days to full fill the chamber having capacity of 1500Mt. So each day 75 Mt required to enter potato inside chamber.

Q= (M)(C)(ΔT) Where Q=The quantity of heat in kW

M=75000 kg/day

C= 3.6 kJ/kg K

ΔT = (20-2) (°C)

Q=56.25kW

Respiration load:

Q = (M) (respiration heat)

M=1500000 kg

Respiration heat= .0325 kJ/kg hr

Q=13.54kW

Human occupancy: -

Assuming number of occupants working in cold storage be 3 and working for 10 hours in a day.The amount of heat dissipated by them is .24KW at 4 °C (each). Hence heat load due to human occupancy is given by

Q = ((3)(10)(.24)(3600)) / ((24)(3600))

Q= 0.3 kW

Equipment load :-(From lighting, evaporators etc.) Here it is assumed that 10 KW is required for this purpose so the equipment loads

Q=10kW

Total cooling Load = Heat transmission through walls + Heat transmission through ceiling + Airchange heat load + Product load + Respiration load + Human occupancy + Equipment load

Total cooling Load = 99.7842 kW

Total cooling Load = 28.50977 TR

Take 10 % more total cooling load for safety purpose so total new cooling load will be

Total cooling load = 30 TR

Design of Mechanical system

As per the design criteria we have to maintain the temperature inside the cold storage with in the limit of 0-6^{0}C and the condenser temperature is 40^{0}C so the refrigeration cycle run within the limit of the condenser temperature and evaporator temperature. Here condenser temperature depends upon the atmosphere temperature that is maximum temperature in summer which is 40^{0}C and evaporator temperature depend upon cold storage temperature which is maintain inside the cold storage so let us cycle will run evaporator temperature at -15^{0}C & condenser temperature at 40^{0}C & one more thing assume that there are 5^{0}C of superheating at a suction of compressor

Refrigerant used -NH_3 (R717)

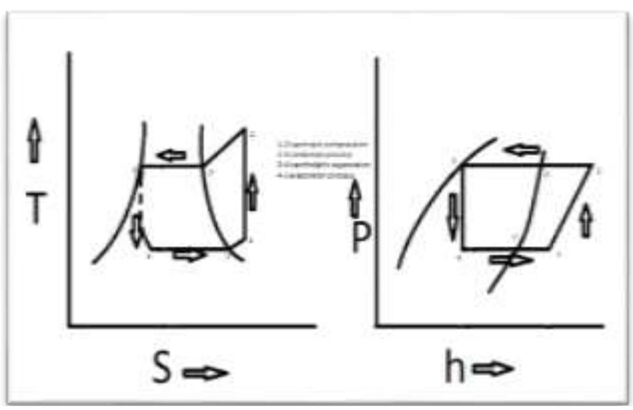

Figure 6 T-s and P-h diagram of vapour compression refrigerationcycle

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

From saturated property of Ammonia (R717)

Table 5 Saturated property of ammonia[11]

Temperature 0C	Pressure in Bar	vf(m3/kg)	vg (m3/kg)	hf(kj/kg)	hg (kj/kg)	sf (kj/kgk)	sg (kj/kgk)
-15	2.263	1.519	.509	112.17	1424.91	.4564	5.5423
40	15.55	1.726	.0833	371.47	1472.02	1.3579	4.8728

NowCp at -15^0C = 4.509 kj/kg k
Cp at 40^0C = 4.999 kj/kg k
Total cooling load for 1500 MT = 30 TR
For process 1-2 isentropic compression
$S_1 = S_2$
$(s_g + cp \ln (T_{sup}/ T_{sat})) -15^0c = (s_g + cp \ln (T_{sup}/ T_{sat}))$ 40^0c
$T_{sup} = 91.10^0C$
Now
$h_1 = h_{g1} + cp (T_{sup} - T_{sat})$
h_1 = 1447.464 kj/kg
Now
$h_2 = h_{g2} + cp (T_{sup} - T_{sat})$
h_2 = 1727.4689 kj/kg
For process 3-4 isenthalpic expansion.
$h_3 = h_{f3} = h_4$ = 371.47 kj/kg
COP = (refrigeration effect / work done)
Refrigeration effect = $h_1 - h_4$ = 1075.994 kj/kg
Work done = $h_2 - h_1$ = 280.0049 kj/kg
COP = 3.8492
Horse power needed to produce 30 TR
COP = (Total TR / Power)
3.8492 = ((30×3.5)/ Power)
Power = 28 kW
Power = 38 HP
For safe limit HP take 25% more than calculated.
So
Total power = 50 HP
Calculation for mass flow needed for 30 TR
$TR = m_r(h_1 - h_4)$
m_r = .09762 kg/s
m_r = 351.432 kg/hr

Design of compressor

At state no 1 specific volume v_{g1} = .509 m^3/kg
Volumetric flow rate = $m_r \times v_{g1}$
Volumetric flow rate = 178.87 m^3 /hr
For compressor design volumetric efficiency is assume to be 80% so actual volume flow rate will be
η_v = (actual volume flow rate / Theoretical volume flow rate)

Actual volume flow rate V_{a1} = 143.096 m^3/hr

Assume there is single compressor having capacity 50 HP have 4 cylinder and the ratio of L/D (length of stroke / bore diameter)=1.5 and RPM range from 500 to 1000.
So
Actual volume flow rate = no of cylinder $\times(\pi/4)\times D^2\times L\times RPS$
D = 9.4 cm
L = 14.17 cm

Design of Condenser

Condenser load Q_c = evaporator load + work of compressor
Q_c = 105 +28
Q_c = 133 kW
Now assume that initial temperature of water Ti =30 ^0C and after passing condenser tube its final temperature Tf = 38 ^0C so rise in temperature will be 8 ^0C
Calculation of mass flow rate of water required for condenser load.
$Q_c = m_w\times Cp\times(T_f - T_i)$
m_w = 3.971 kg/s
m_w = 14297.65 kg/hr
In gallon per minute
Volume = 62.94816 gpm
Now assume that there are 15 no of tube in condenser so gpm per tube.
Gpm per tube = 62.94816/15
Gpm per tube = 4.19
From figure 5 calculate the value of U (over all heat transfer coefficient) for scale factor .003
From figure 5 and for .003 scale factor value of overall heat transfer coefficient U = 363.1616 watt / m^2k
from the figure 5 LMTD of Condenser calculate Θ_m
$Q_c = U\times A\times\Theta_m$
A = 1.3127 m^2
$A = \pi\times D\times l$
Take diameter of tube 2 inch that is .0508 m
l = 10 m
Length of each tube = 10 m

Each tube having 4 no of turns so each turn having length = 2.5 m

Design of Throttling Device

Throttling device must be capable of expanding 143.096 m^3/hr and must operate in the pressure range of 2.263 bars to 15.55 bars

Design of Evaporator

Potato need minimum 50 CFM/MT
Total CFM for 1500 MT = 50 ×1500
CFM for 1500 MT = 75,000 CFM
If there are 3 units of industrial air cooler use so each unit CFM will be = 25,000
And air volume each unit = 42,475.5 m^3 / h

So industrial cooler requirement max rang of air volume = 42,475.5 m^3 /h
Mass flow rate control (ammonia) = 351.432 kg/h

RESULT

We have successful design mechanical system for cold store of potato having storage capacity of 1500 MT including design of compressor, condenser, throttling device and industrial cooling fan coil unit.
Our system has achieved favrable condition as shown by the data collection from our visiting side named TIRUPATI COLD STORAGE located at village HARSODAN, Ujjain district.

Heat load calculation data

Table 6 Heat load result

S no.	Heat source	Heat Load
1	Heat gain through west wall	2.855 kW
2	Heat gain through north wall	2.255 kW
3	Heat gain through south wall	2.255 kW
4	Heat gain through east wall	2.855 kW
5	Heat gain through ceiling	3.4 kW
6	Air change heat load	6.074 kW
7	Product load	56.25 kW
8	Respiration load	13.54 kW
9	Human occupancy load	0.3 kW
10	Equipment load	10 kW
11	Total heat load	99.7842 kW
12	Total load	28.50977 TR

Refrigeration cycle calculations data

Table 7 Refrigeration cycle result

S no.	Name	Result
1	Enthalpy at suction of compressor (h1)	1447.464 kj/kg
2	Enthalpy at exit of compressor (h2)	1727.4689 kj/kg
3	Enthalpy at exit of condenser (h3)	371.47 kj/kg
4	Enthalpy at entry of evaporater (h4)	371.47 kj/kg
5	Coefficient of performance	3.8492
6	Refrigerant mass flow rate (mr)	351.432 kg/hr

Design calculation result of compressor

Table 8 Compressor result

S no	Compressor specification	Result
1	Actual volume flow rate Va1	143.096 m3/hr
2	Reciprocating compressor capacity	50 HP
3	Number of cylinder	4
4	RPM rang	500-1000
5	Bore diameter	9.4 cm
6	Length of stoke	14.17 cm

Design calculation result of condenser

Table 9 Condenser result

S no	Condenser specification	Result
1	Condenser load Qc	133 kW
2	mass flow rate of water required for condenser load Qw	14297.65 kg/hr
3	outside surface area of condenser A	1.3127 m2
4	Outside diameter of condenser	50 mm
5	Number of tube	15
6	Length of each tube	10 m
7	Number of turn of each tube	4

Design calculation result of throttling device

Table 10 Throttling result

S no	Specification of throttling device	Result
1	Design pressure at entry of throttle	15.55 bar
2	Design pressure at exit of throttle	2.263 bar

Design calculation result of evaporator

Table 11 Evaporator result

S no	Specification of evaporator	Result
1	CFM for 1500 MT	75000 CFM
2	Number of industrial air cooler	3
3	air volume each unit	42475.5 m3/h
4	Mass flow rate control (ammonia)	351.432 kg/h

CONCLUSION

A cold storage for potato at village HARSODAN district Ujjain (m.p) has been designed and total heat load capacity of 30 TR with maximum C.O.P. of 3.8492.on the basis of that heat load and COP successful design of mechanical refrigeration system completed. This paper allows to make similar calculation for the reader to design different store and obtain an approximate refrigeration requirement. it also give the various factor that use in calculating heat load and design of refrigeration system and also give some idea of their importance.

REFERENCES

1. E book on potato storage central potato research institute shimla (An ISO 9001:2008 certified institute) http://cpri.ernet.in/?q=node/223
2. Priyanka Sakare," Design of Cold Storage Structure For Thousand Tonne Potatoes" International Journal of Agriculture and Food Science Technology. ISSN 2249-3050 Volume 5, Number 3 (2014), pp. 171-178
3. source cengle and boles "thermodynamics an engineering approach "7rd edition McGraw-Hill Education, 25-Jan-2010 pp- (10-1 to 10-4)
4. Ugwu, Hyginus Ubabuike*, Ogbonnaya, Ezenwa Alfred "and Adaptation of a
5. Commercial Cold Storage Room for Umudike Community and Environs" IOSR Journal of Engineering Umudike, P.M.B. 7267, Umuahia, Abia State, Nigeria.
6. Roy J Dossat, "Principles of Refrigeration", AGenral Introduction of Cooling Load Calculation, Eighth impression 2011,Fourth edition Pearson Education in south Asia
7. R C Sachdeva, "Fundamental of Engineering Heat and Mass Transfer, Fundamentals of convection Heat Transfer", Fourth Edition, New Age Publishers
8. C.P. Kothandaraman, S. Subramanvan, "Heat and Mass Transfer Data Book" , Edition -8, illustrated, New Age Publishers
9. Ashrae Hand book " HVAC application" published 2011 ISBN(s) 9781936504048
10. Manohar Prasad, "Refrigeration and Air Conditioning, cooling and heating local calculation", New Age Publishers, second edition
11. Cold Storage for fresh horticulture produce not requiring pre cooling before storage(Technical Standered Number NHB-CS-TYPE 01- 2010)

12. Manohar Prasad, Data Book," Refrigeration and Air Conditioning", New Age Publishers

AUTHOR BIBLIOGRAPHY

	**Sharad Chaudhary** Ph.D (Thermal Engineering) Asstt. Professor Institute of Engineering & Technology DAVV- Indore, MP India Ph (O) 0731-2361116
	**Virendra Sharma** M.E. with specialization in Design & Thermal Engineering, Institute of Engineering & Technology DAVV- Indore, MP India