RESEARCH ARTICLE OPEN ACCESS

Energy Wastage Estimation of a Cold Storage

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ABSTRACT:
Energy consumption of a cold storage was measured for different storage temperatures. Suction temperature and pressure temperature of the compressor and working time of the compressor were determined to reach evaporator setup temperatures. An axial fan located back of the evaporator was used to distribute the cooled air into the cold store. An electrical heater was used to defrost. The compressor suction temperature of ammonia vapour variedbetween273K–271Kand 305K–308K respectively. Compressor suction pressure(p_1)=3.5 Kg/cm^2 and discharge pressure (p_2)=10.5Kg/cm^2
KEY WORDS: Cold storage, major components of a cold storage, energy consumption, energy wastage, programming.

I. INTRODUCTION

Energy auditing in a integral part of energy conservation and energy management is also part and parallel of conservation. Damage and supply gap is large energy to lead to similar natural defects, Energy disaster such as Tsunami and earth quake. The next generation generating yet to come will be completely light blind. It is because power never be available after this disaster and not ever rehabilitate the reconstruction of buildings. To avoid the energy calamity proposed auditing report use the innovative energy utilization schemes through which the ferocious of situation might blindness can be eradicated. Cold Storage is a special kind of room, the temperature of, which is kept very low with the help of machines and precision instruments. India is having a unique geographical position and a wide range of soil thus producing variety of fruits and vegetables like apples, grapes, oranges, potatoes, chillies, ginger, etc. Marine products are also being produced in large quantities due to large coastal areas. The present production level of fruits and vegetables is more than 100 million MT and keeping in view the growth rate of population and demand, the production of perishable commodities is increasing every year. The cold storage facilities are the prime infrastructural component for such perishable commodities. Besides the role of stabilizing market prices and evenly distributing both on demand basis and time basis, the cold storage industry renders other advantages and benefits to both the farmers and the consumers. The farmers get opportunity of producing cash crops to get remunerative prices. The consumers get the supply of perishable commodities with lower fluctuation of prices. Commercially apples, potatoes, oranges are stored on large scale in the cold storages. Other important costly raw materials like dry fruits, chemicals, essences and processed foods like fruit juice/pulp, concentrate dairy products, frozen meat, fish and eggs are being stored in cold storages to regulate marketing channels of these products. Energy consumption of an experimental cold storage was measured for different storage temperatures. Suction temperature and pressure temperature of the compressor and working time of the compressor were determined to reach evaporator set up temperatures.

II. MODEL DEVELOPMENT:

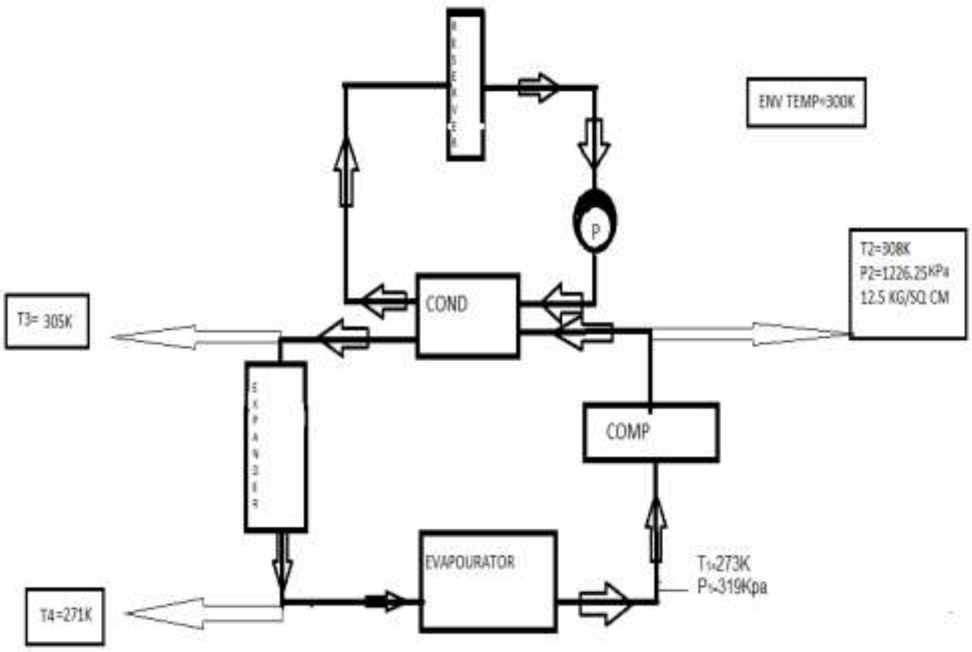
The salient components of vapour compression refrigeration system used in Indian cold storage system are: evaporator, compressor, condenser and manually operated expansion valve. The type of the cold storage are
1) Vapour campression refrigeration cycle is used
2)Ammonia refrigerent is used in the cycle
For the analysis of the various parameter of the Jalpaiguri cold storage we make some **assumption**

1. The compression and expansion process are an isentropic process ie. Entropy of those process are remains same
2. The ammonia vapour behaves as an ideal gas

3. Specific heat, specific heat ratio and local gas constant does not change in different temperature and pressure.
4. The specific heat capacities at constant pressure and constant volume processes, and the ratio of specific heat and the individual gas constant - R – for ammonia vapour at 20 °c and 1a.t.p are given below

C(p)= 2.19; C(v)= 1.66 ; γ= 1.31 ; R= 0.53

A typical schematic diagram of the refrigeration stem is shown below



Cold storage

From the above assumption we can calculate following parameters

Compression work $W_c = n/n - 1(P_2V_2 - P_1V_1)$

$= n/n - 1(RT_2 - RT_1)$

$= 78.38$ KJ/ Kg of ammonia

Expansion Work $W_e = n/n - 1(RT_3 - RT_4)$

$= 76$ KJ / Kg of ammonia

net work done W = W(c) – W(e)

= (78.38 – 76) KJ / Kg of ammonia

= 2.38 KJ / Kg of ammonia

Heat absorbed from the evaporator per kg of ammonia

$Q_e = mCp(T_1 - T_4)$

=4.38 KJ / Kg of ammonia

C.O.P = Heat absorbed / Work done

= 4.38 / 2.38

= 1.84

Volume of ammonia per cycle of compression per cylinder

$V_1 = \frac{\pi}{4}D^2L$ [from the observation table we can find bore and stroke]

$= 0.002796\ m^3 \approx 0.0028 m^3$

So work of compression per cycle per cylinder

$W_c' = \frac{n}{n-1}(P_2V_2 - P_1V_1)$

$= \frac{n}{n-1} P_1 V_1 \{(\frac{P_2}{P_1})^{\frac{n}{n-1}} - 1\}$

$= 4.226 \times 320 \times 0.0028 \times (1.3846 - 1)$

$= 1.456$KJ / cycle per cylinder

≈ 1.5 KJ / cycle per cylinder

There are two cylinder of a KC 4 type compressor and average R.P.M = 1400

SoWork of compressor per second

$W_c' = (1.5 \times 2 \times 1400)/ 60$ KJ / sec

= 70 KJ/ sec

Mass flow rate of ammonia per second

$= \frac{W_c}{W_c} = \frac{70}{78.38} = 0.893$ Kg / sec

Ton of refrigeration

$= mCp(T_1 - T_2)/3.5$

= 1.178TR

≈ 1.2 TR

Heat dissipated from the condenser

$Q_c = mCp(T_2 - T_3)$

= 5.867 KJ / sec

≈ 6 KW

OBSERVATION:

- Suction pressure of the compressor P_1= 319.9 KPa≈320KPa
- Suction temperature of compressor T_1=273K
- Discharge pressure of the compressor P_2=1226.25KPa
- Discharge temperature of compressor T_2=308K
- Discharge pressure of the condenser P_3=P_2=1226.25KPa
- Discharge temperature of the condenser T_3=305K
- DATA COLLECTION
- Major equipments considered to calculate the energy waste estimation

Equipment name	Number	Stand by
Compressor motor	4p	2
Condenser motor	3p	1
Pump	3p	1

- Minor equipments considered to calculate the energy waste estimation

No of fans	Place	Power
320p	Inside the chamber	72w
36p	On the office	85w
50p	Outside of chamber	72w

No of light	Power	Place
430p	60w	Inside the chamber
50p	40w	In office
10p	280w	Hallozen

MOTOR SPECIFICATION

Motor specification= 3 phase induction motor	
Company name= crompton graves	
m/c no= NADJ54-2RS	
RPM- 1460	
V=415 +(-) 10%	A=27A
BPE=90%	HZ=50+(-) 5%
FRAME	ND160L

PUMP SPECIFICATION

PUMP SPECIFICATIONS	
COMPANY= KSB PUMPS LTD	
SL NO= 9850877	
Q = 500m3/h	H=52M
N-2980RPM	
IN0352D-A52*74	

COMPRESSOR SPECIFICATION

KIRLOSKAR PNEUMATIC CO.LTD	
MODEL – K.C-4	SL.NO-338K1461
BORE =160mm	STROKE=110mm
MAX PR=21KG/C	
RPM=1460	SPEC NO= 338001

Compressor motor running time calculation									
Compressor motor 1					**Compressor motor 2**				
Date	**Start time**	**Stop time**	**Next day stop time**	**Running time**	**Date**	**Start time**	**Stop time**	**Next day stop time**	**Running time**
23-10-15	10.25AM	8.50PM		10H25M					
	11.10PM		7.30AM	8H20M					
24-	11AM	8.50PM		9H50M					
	11PM		9.10AM	10H10M					
25-	2.10PM	5.40PM		3H30M	25-2	10.20AM	7.10PM		8H50m
	11.10PM		6.20AM	7H10M					
26-	10.50AM	3.40PM		4H50M	26-2	3.20AM	4.30PM		13H10M
	11.10PM		5.10AM	6H		6.20PM		2.30AM	8H10M
27-	10.20AM	5.10PM		6H50M	27-2	7.25AM	4.05PM		8H40M
	11.10PM		6.20AM	7H10M		8PM		2.10AM	6H10M
28-	10.50AM	3.40PM		4H50M	28-2	5AM	1.20PM		8H20M
	11PM		8.10AM	9H10M		4.30PM		2.50AM	10H20M
29	10AM	2.10PM		4H10M	1-3	6.10AM	10AM		3H50M
	11.10PM		3.10AM	4H		4.20PM	8.20PM		4H
30	6.40AM	10.50AM		4H10M	2-3	10.AM	2PM		4H
	11.10PM		2.30AM	3H20M		4.50PM	9.40PM		4H50M
31	10AM	2PM		4H	3-3	6.10AM	10.10AM		4H
	11PM		3AM	4H		4PM	8PM		4H
1-11	9.20AM	3.50PM		5H30M	4-3	5.40AM	11AM		5H20M
	2.10PM	7.30PM		5H10M		11.10PM		5.25AM	6H15M
2	6.10AM	9.50AM		3H40M	5-3	10.10AM	2.10PM		4H
	4.40PM	9.20PM		4H40M		11.10PM		3.40AM	4H30M
3	6.20AM	11.30AM		4H10M	6-3	12.40PM	5PM		4H20M
	8.10PM	11.30PM		3H20M					
4	10.10AM	2.30PM		4H20M	7-3	3AM	7.10AM		4H10M
	11.10PM		8AM	9H10M					
5	10.10AM	6.40PM		8H30M					
	11.10PM		6.10AM	7H					
6					9-3	10.20AM	4.40PM		6H20M
	11.10PM		4.20AM	5H10M					
7	6.25AM	10.30AM		4H05M	10-3	12.20PM	4.50PM		4H30M
	4.30PM	9.50PM		5H20M		11.10PM		3.20AM	4H10M
8	10AM	2.30PM		4H30M	11-3	6AM	10.50AM		4H50M
	11.10PM		3.40AM	4H30M		4PM	8.20PM		4H20M

9	10.10AM	3.30PM		5H20M	12-3	6.10AM	11.50AM		5H30M
	11.10PM		3.50AM	4H40M		4.10PM	9PM		4H50M
10	10AM	2.30PM		4H30M	13-3	6AM	10.40AM		4H40M
	11PM		3.40AM	4H40M		11PM		3.20AM	4H20M
11	10.10AM	2.50PM		4H40M	14-3	6.10AM	10.20AM		4H10M
	11.10PM		4.50AM	5H40M		4.20PM	9.40PM		5H20M
12	10AM	2.30PM		4H30M	15-3	6AM	10.20AM		4H20M
	11PM		3.40AM	4H40M		4PM	8.20PM		4H20M
13	10.10AM	2.20PM		4H10M	16-3	6.20AM	10.50AM		4H30M
	11PM		3.30AM	4H30M		11.10PM		3.30AM	4H20M
14	10AM	2.30PM		4H30M	17-3	6.10AM	10.20AM		4H10M
	11.10PM		3.50AM	4H40M		11.10PM		3.30AM	4H20M
15	10.30AM	4.10PM		5H40M	18-3	6AM	11.30AM		5H30M
	11.20AM		3.30AM	4H10M		4PM	8.20PM		4H20M
16	10AM	2.20PM		4H20M	19-3	6.10AM	10.40PM		4H30M
	11PM		3.30AM	4H30M		11.10PM		3.50AM	4H40M
17	10.20AM	2.40PM		4H20M	20-3	6.30AM	11.10AM		4H40M
	11.10PM		3.40AM	4H30M		4.10PM	8.20PM		4H10M
18	10AM	2.30PM		4H30M	21-3	6.10AM	10.30AM		4H20M
	11.10PM		4.50AM	5H40M		4.20PM	8.50PM		4H30M
19	10.20AM	2.40PM		4H20M	22-3	6AM	10.20AM		4H20M
	11.20PM		3.50AM	4H30M		4.10PM	8.50PM		4H30M
20	10AM	2.20PM		4H20M	23-3	6.20AM	10.50AM		4H30M
	11.10PM		3.20AM	4H10M		11.10PM		3.50AM	4H40M
21	6.10AM	11.50AM		5H40M					
	11.10PM		4.30AM	5H20M					
22	6.05AM	12.30PM		6H25M					
	11.10PM		5.30AM	6H20M					
23	10.20AM	2.40PM		4H20M					
	11.10PM		420AM	5H10M					
TOTAL RUNNING TIME - 603.6H; APPROXIMATLY WE CAN TAKE 604 H									

CALCULATION

Power consumed by the light and fan can be calculated by the given formula

KWh = $\frac{P\ (watt\ )\times hour\ \times no\ of\ fan\ or\ light}{1000}$

POWER CONSUMED BY THE FAN

NO OF FANS	POWER	FAN TYPE	RUNNING TIME IN 24H	RUNNING TIME IN ONE MONTH	KWH IN 24H	KWH IN ONE MONTH
320	72	INDUSTRIAL		604		13916.16
50	72	INDUSTRIAL	12		43.2	1339.2
35	85	USHA	7		20.825	645.57
TOTAL POWER CONSUMED BY THE FAN IN ONE MONTH =15900.93						

POWER CONSUMED BY THE LIGHT

NO OF LIGHT	POWER	RUNNING TIME IN 24H	KWH IN 24 H	KWH IN ONE MONTH
500P	60W	2H	60	1860
50P	40W	4H	8	248
5P	250W	7H	8.75	271.25
TOTAL POWER CONSUMED IN 24 HOURS=76.75				
TOTAL POWER CONSUMED IN ONE MONTH =2379.25				

Power consumed by the 3 phase induction motor can be calculated by the given formula

P(watt)= $V \times I \times \cos\emptyset$

V= voltage of the motor
I = current flow through the motor
$\cos \emptyset$ = power factor = 0.85

We can find V & I from the volt meter and ammeter
Power factor of W.B.S.E.D.C.L is 0.85 (we found these from google)

POWER CONSUMED BY THE CONDENSER MOTOR

MOTOR NAME	VOLTAGE(V)	CURRENT FLOW(AMP)	POWER FACTOR	watt	KWh
C.G	415	12	0.85	4233	4.233

So power consumed by the condenser motor in one hour = 4.233 KWh
POWER CONSUMED BY THE MOTOR IN ONE MONTH = **2556.732 KWh**

POWER CONSUMED BY THE COMPRESSOR MOTOR

MOTOR NAME	VOLTAGE(V)	CURRENT FLOW(AMP)	POWER FACTOR	watt	KWH
1	415	125	0.85	44093.75	44.09

Power consumed by the compressor motor in one hour = 44.09 KWh
POWER CONSUMED BY THE COMPRESSOR MOTOR IN ONE MONTH = **26630.36KWh**
We make a program of P(watt)= $V \times I \times \cos \emptyset$ from where we can make a graph of I Vs P

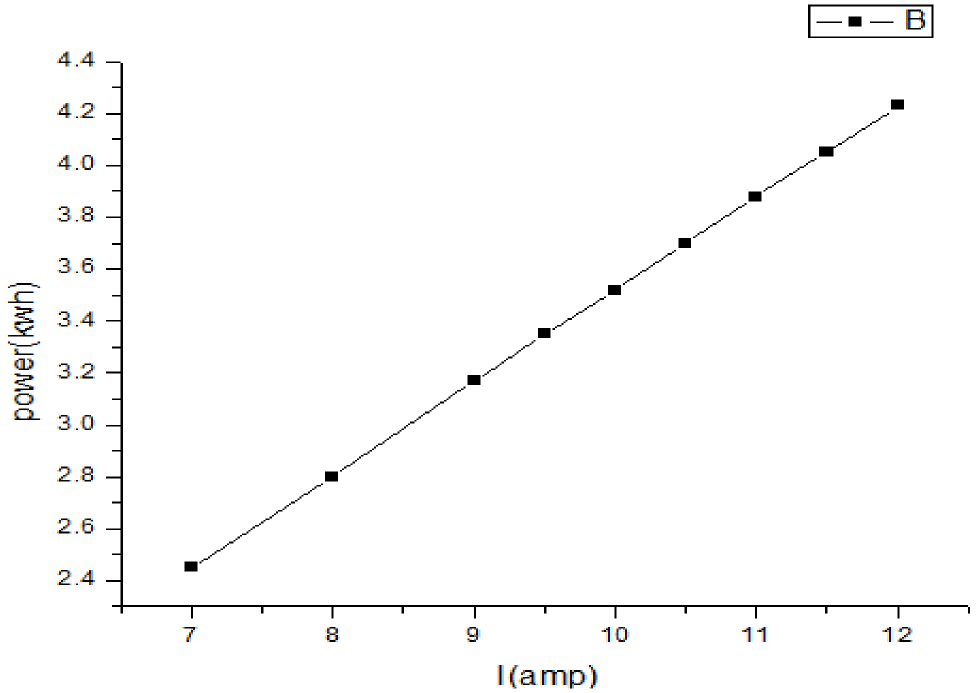
PROGRAMMING:

```
#include<stdio.h>
#include<conio.h>
#include<math.h>
Void main()
{
        Float   P,I;
        Int       V=415, n=10 , i;
        Float   cos Ø =0.85;
        For(i =0; i<n; i++)
        {
                Printf{“\n Enter the the value of I”};
                Scanf(“%f”, &I);
                P = v*I* cos Ø;
                Printf(“I=%f, P=%”, I, P);
}
Getch();
}
```

RESULT & DISCUSSION:

In the above program we give the input value of I =12 to I= 7
And take the output P and make a graph P Vs I

I(amp)	12	11.5	11	10.5	10	9.5	9	8	7
P(KWh)	4.23	4.05	3.88	3.7	3.52	3.35	3.17	2.8	2.45



Form data we can say that

OCTOBER 23 to NOVEMBER 23 unit runs more over 24 hours.
Total running time of the plant = 604 hours
From the electricity bill 23rd October to 23rd November unit consumed by the plant
= 21515.5KWh(normal) + 2484.25KWh(peak) + 24442.25KWh(off peak)
= **48442KWH**

Theoretical energy consumed by the plant in one month

Device	Condenser motor	Compressor motor	Light	Fan
Unit consumed in one month	2556.73	26630.36	2379.25	15900.93
Unit consumed in one day	82.47	859.04	76.75	512.93

So total theoretical energy consumed by the plant in one month =**47467.27 KWH**
Energy wastage in one month = (48442-47467.27)KWH
=974.73 KWH
There is a big difference in actual energy consumed and theoretical energy consumed obviously there is a energy wastage. We must pay extra cost for these energy wastage. Average industrial bill = 7.5 Rs

ENERGY WASTAG AND EXTRA COST REQUIRED HAS BEEN CALCULATED IN THE GIVEN BOX

Energy wastage	In one hour	In one day	In one month	In one year
KWh	1.31KWh	31.44KWh	974.73KWh	11696.76KWh
Extra cost required	Rs=9.825	Rs= 235.8	Rs=7310.47	Rs=87725.7

III. CONCLUSION

It has been observed that the actual energy consumption of a cold storage 48442 KWh per month and theoretical energy consumption is 47467.27 KW per month. So, a gap of 974.73 KWh per month is found between the theoretical and actual energy consumption by a cold storage plant. If this gap is fulfilled then a savings of Rs 7311 /- per month will be obtained which will **amount to Rs 87726 /- per year.**
To save energy the following practices must be implemented
1. Reducing Heat Loads
2. Uses of latest energy saving equipments
3. Proper Insulation

4. Efficient maintenance practices
5. Automation & Integration
6.Repless all lights and Uses of LED

There are other factor which contributes to the total energy consumption, which are (i) lights (total 556 pcs) , (ii) fans (total 405 pcs). To increase the efficiency, conventional lights will replaced by energy efficient devices that is LED, CFL etc.

If we replace three compressors for three chambers with a single equivalent compressor which will deliver the same amount of load, then maximumenergy will be saved

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