ENERGY AUDIT AT ABOO BAKER ICE PLANT

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Abstract: Energy demand keeps rising day by day so that it is essential to decrease the amount of energy consumption for that energy audit is needed. For conservation of energy the best option is energy audit. EA is the process of when, where, why and how the energy is used in a plant or building. Normally, energy auditing is carried out and performed by certified energy auditors and energy managers. By conducting energy audit process in industry, employees try to conserve the energy in day-to-day action.

This project determines to find out cooling load estimation in Aboo baker ice plant, Ratnagiri. The main goal and objective of this project is to give and make available ways to decrease energy utilization and consumption per unit of product output so as to decrease operating cost.

A well-known cooling load calculation and estimation procedure has been adopted and utilise by American Society of Heating, Refrigeration and Air conditioning Engineering, used in this project to predict the cooling load added due to types of wall, windows, roofs, infiltration, calculation of all parameters and heat loads hence to give them a better solution. Results of these calculations could be used to implement the type of system into the company. Calculation of cooling load is estimated using ASHRAE handbook procedure and the agreement was found to be unsatisfactory. Cooling load per TR is more compared to other ice plant hence we gave them a better solution/suggestion to implement the system into the company.

***Index Terms* –** Ice plant, Energy audit, Cooling load, ISHRAE.

I. Introduction

In any business, a large commercial facility or manufacturing operations, it is important to take advantage of any tips, programs and incentives that will help you to save money on your energy consumption. One such initiative is an energy audit. Energy audit reveal your usage patterns and identify waste. Need of EA is to maximize energy efficiency and minimize loss.
Energy audit will helps us to give ideas and to understand much more about the ways energy is used in different companies, firms, industries and then help to identify the sectors or areas where waste can be available or can be occur and shows the way for improvement. So to study the actual energy audit process and to estimate the cooling load in order to reduce the energy consumption in Aboo Baker ice plant we selected this project.

Our project primarily aims to estimate the cooling load of ice plant and hence to save the energy cost, to increase the efficiency and identifying possible energy saving opportunities

II. Literature Review:

Literature material referred for this project were books, different articles, government publications, handbooks, magazines, research papers which are published in international books, journals and internet. Major references are from the journals and handbooks of ISHRAE and ASHRAE, Bureau of Energy Efficiency, Government of India.

As this project idea or topic is related to energy audit at plant level, different energy audit and energy conservation and management adopted from different industries, performance calculation of equipment, different energy audits were studied. In order to get complete knowledge and understanding of energy conservation and management, complete literature view, study was undertaken.

The research problem required following study themes:

I. Environmental, economic and social benefits
II. Need of Energy Management and Energy Audit
III. Different Energy Efficient Technologies
IV. Barriers of Energy Management and Energy Audit
V. Energy Audit and Energy Management training

III. Collected Data:

By using above instruments and by taking actual measurement of ice plant, following data is listed.

- Weight per can: 250 kg
- Freezing time: 72 hrs.
- Total capacity: 200 tons.
- Brine temperature range: -13.33 to -10 ˚C
- Ice can dimension: 183cm*55cm*27 cm
- No. of operators: 2
  8 (during ice removal)
- Volume of cold storage: 2285.8625 m^3
- Area of roof: 312.778 m^2

- Area of floor: 294.95 m^2
- Area of open space: 46.3 m^2
- Area of wall: 571.25 m^2
- Instruments used: Thermometer, Anemometer, Hygrometer
- No. of can: 800
- Humidity: 51.8% (inside)
  47.8% (outside)
- Temperature: 36 ˚C (outside)
  29˚C (inside)
- Wind speed: 2 m/s

IV. Refrigeration load calculations:

1. Solar & transmission Heat Gains:

The solar radiation striking the outside surfaces of a building may contribute appreciably to the peak load on the air conditioning and refrigeration equipment and must, therefore, be considered.

Table 1: Design data

FACTORS	REFERENCE (ISHRAE HANDBOOK)
Daily Range ˚F =15	Page 1.5
Temperature differential correction= -2˚F	Page 1.25
U=1.25(˚F per Btu)/(hr)(sq. ft)	Page 1.21(wall) Brick
U=0.667(˚F per Btu)/(hr)(sq. ft)	Page 1.21(roof) Metal Sheet
U= 1.098(˚F per Btu)/(hr)(sq. ft)	Page 1.21(floor) Concrete

Heat gains (through walls/ Roof/floor) = Area * (outside temp - inside temp + temp correction) *(heat transfer co-efficient "U")

1. Heat gain through wall:

- North facing wall:

=Area * (outside temp - inside temp + temp correction) * (heat transfer co-efficient "U")
=(((34.7*7)-10.8-21.84)*10.764)*(96.8-84.2-2)*1.25
=29987.91198Btu/hr

- East facing wall:

=Area * (outside temp - inside temp + temp correction) * (heat transfer co-efficient "U")
=(((8.5*7)+(0.5*8.5*1.5))* 10.764)* (96.8-84.2-2)*1.25
=9395.2901 Btu/hr

- South facing wall:

=Area * (outside temp - inside temp + temp correction) * (heat transfer co-efficient "U")
=(((34.7*7)-10.8-2.86)* 10.764)* (96.8-84.2-2)*1.25
= 32694.8965Btu/hr

- West facing wall:

=Area * (outside temp - inside temp + temp correction) * (heat transfer co-efficient "U")
=(((8.5*7)+(0.5*8.5*1.5)* 10.764)* (96.8-84.2-2)*1.25
=1697.5966 Btu/hr

- Total Heat gain through wall = H.G.(East+ West+South+North)
  = 73775.69518Btu/hr

2. Heat gain through roof = Area * (outside temp - inside temp + temp correction) * (heat transfer co-efficient "U")
   =(2*34.7*3.9764*10.764)* (96.8-84.2-2)*0.667
   =21001.72 Btu/hr
3. Heat gain through floor = Area * (outside temp - inside temp + temp correction) * (heat transfer co-efficient "U")
   =(34.7*8.5*10.764)* (96.8-84.2-2)*1.098
   =36951.348 Btu/hr

- Total Heat Gain =Heat gain (wall)+ Heat gain (roof)+Heat gain (floor)
  = 189681.8312Btu/hr

2. Infilteration of Outside Air:

Outside air which is much higher in temperature and moisture content enters cold storage because of door openings for loading or unloading of products and due to infiltration through open space like windows and doors without curtains and also due to minor cracks around walls.

a. Outside air sensible heat gain in BTU/hr=(Infiltration cfm)*1.08*(temp. difference between outside and inside)
Now, Infiltration through open space-
Q= A*V
Where, A – Open Space Area = 46.3m^2 = 498.369 ft^2
V- Velocity = 2m/s = 393.72 ft/min
Q= 196217.84 CFM
Outside Air Sensible Heat gain: = 196217.84 * 1.08 * (98.6-84.2)
= 3051579.889 BTU/Hr

b. Outside Air Latent heat gain = (Infiltration CFM)*0.68*(grains/lb difference between inside and outside room temperature)
= 196217.84 *0.68*(w1-w2)
= 196217.84 *0.68*(0.0175-0.013)
= 600.42BTU/Hr

3. Internal loads:

- Lights :

Typical requirement will be 1 to 1.5 W/ft^2 i.e 10 to 5 W/m^2 . Based on estimation of total lighting wattage in entire cold room space, using this norm, sensible heat gain due to lights in Btu/hr can be calculated by using multiplier of 3.42 Btu/W.

Lights = (Kw)* no. of tubelights* conversion factor* 3410
= $(18*10^{-3})$* 27 *0.8 * 3410
= 1325.808 BTU/hr

- Occupancy:

People working in cold storage chambers for loading and unloading of products, dissipate both sensible and latent heat depending on temperature.

For normal temperature 27˚c , i.e 82˚F (from ISHRAE Handbook page1.26)
Sensible heat = 450 BTU/hr
Latent heat = 1000 BTU/hr
Total Internal Load= 1325.808+[(450+1000)*8]= 12925.808 BTU/Hr

4. Safety factor (For total refrigeration load):

Based on estimation of main elements of refrigeration load as above and after adding a safety margin of 5%, the total refrigeration load is calculated.
= 5%

Total heat gain:
= Solar & transmission Heat Gains + Infilteration of Outside Air + Internal loads + safety factor
=3254787.998 Btu/hr
=271.22 TR

Current situation:

- The estimated cooling load was much higher due to large amount of open spaces in the ice plant.
- The absence of insulation layer on walls, roof and floor considerably increases cooling load.
- Since ice cans are stored in between two stories without insulation, the heat gain is large.
- Also, numbers of workers are more which increases internal load.
- Duration of day at which water is installed in ice cans is generally at noon.
- Water storage tanks are built underground but are exposed to sunlight without any shade.

Suggested solutions to reduce cooling load:

- For insulation of walls, roof and floor (from both sides) we select Elastomeric foam.
  U factor of elastomeric foam is 0.28
- Elastomeric foam resists moisture absorption and also it is easy to install.
- To reduce infiltration due to open spaces can be reduced by using plastic strip curtains.

Changed calculations:

1. Heat gain through wall:

- North facing wall:

=Area * (outside temp - inside temp + temp correction) * (heat transfer co-efficient “U”)
=(((34.7*7)-10.8-21.84)*10.764)*(96.8-84.2-2)*0.28
=6717.2922Btu/hr

- East facing wall:

=Area * (outside temp - inside temp + temp correction) * (heat transfer co-efficient “U”)
=(((8.5*7)+(0.5*8.5*1.5))* 10.764)* (96.8-84.2-2)*0.28
= 2104.544Btu/hr

- South facing wall:

=Area * (outside temp - inside temp + temp correction) * (heat transfer co-efficient “U”)
=(((34.7*7)-10.8-2.86)* 10.764)* (96.8-84.2-2)*0.28
= 7323.6568Btu/hr

- West facing wall:

=Area * (outside temp - inside temp + temp correction) * (heat transfer co-efficient "U")
=(((8.5*7)+(0.5*8.5*1.5)* 10.764)* (96.8-84.2-2)*0.28
= 380.2616Btu/hr

Total Heat gain through wall = H.G.(East+ West+South+North)
=16525.7546Btu/hr

2. Heat gain through roof

= Area * (outside temp - inside temp + temp correction) * (heat transfer co-efficient "U")
=(2*34.7*3.9764*10.764)* (96.8-84.2-2)*0.28
=8816.315 Btu/hr

3. Heat gain through floor

= Area * (outside temp - inside temp + temp correction) * (heat transfer co-efficient "U")
=(34.7*8.5*10.764)* (96.8-84.2-2)*0.28
=9422.93 Btu/hr

Total Heat Gain =Heat gain (wall)+ Heat gain (roof)+Heat gain (floor)
= 34764.9996Btu/hr

4. Infilteration of Outside Air:

By installing plastic strip curtains with maximum thickness we can entrap the heat infiltration through doors and windows. This will eventually eliminate the infiltration load.

5. Internal loads:

- Lights:

Typical requirement will be 1 to 1.5 W/ft^2 i.e 10 to 5 W/m^2 . Based on estimation of total lighting wattage in entire cold room space, using this norm, sensible heat gain due to lights in Btu/hr can be calculated by using multiplier of 3.42 Btu/W.

Lights = (Kw)* no. of tubelights* conversion factor* 3410
= ($18*10^{-3}$)* 27 *0.8 * 3410
= 1325.808 BTU/hr

- Occupancy:

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Sensible heat = 450 BTU/hr
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Total Internal Load= 1325.808+[(450+1000)*8]= 12925.808 BTU/Hr

6. Safety factor (For total refrigeration load):

Based on estimation of main elements of refrigeration load as above and after adding a safety margin of 5%, the total refrigeration load is calculated.
= 5%

Total heat gain :

= Solar & transmission Heat Gains + Infilteration of Outside Air + Internal loads + safety factor
=49016.665 Btu/hr
=4.08TR

V. Results:

Table 2: Result

Current cooling load	Estimated cooling load
271.22TR	4.08 TR

- After installation of insulation and curtains, cooling load is considerably reduced. Hence the ice formation time will get reduced from 72 hrs.
- With the use of skilled labour the working efficiency can be increased.
- If the storage tanks are covered with roof or shelter, then the temperature of water entering ice plant will be low and ice formation will be quick and easy.
- The water installing within ice cans should be done at night which will reduce temperature of water.

VI. Conclusion:

The main expectation of this project was to built on the previous energy efficiency work that had been accomplished and further reduced consumptions and costs, as such it can be seen as very successful: it accomplish to discover measures which reduce the consumption in around 267.14 TR which translates in around great economical efficiency.

By implementing various suggestions given above, the ice plant can work with less amount of cooling load required. This enhancement will be useful in both economic and environmental way. This will help in reducing production time of ice and the energy bills.

From this perspective, no doubts arise, it is highly valuable project, specially it can be replicated in remaining factories.

VII. References:

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VIII. Acknowledgment:

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