INTERNSHIPSTUDIO

Internship Title:

Energy Management and Conservation

Work From Home
Internship Program 2020

Start Date: 23/06/2020
End Date: 01/08/2020

Project Title: Performance Analysis of a Refrigeration System

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Problem Statement

You are appointed as a Consultant to an Ice Manufacturing unit in Ahmednagar, Maharashtra with a capacity of 25 TPD (Tonnes per day) to improve their performance and Energy efficiency.

The Daily output of the plant is 15 Tonnes of block ice at a temperature of (- 8°C).The input water quantity is 16.5 m3 of water at temperature of (+ 30°C). The higher water consumption is due to loss of ice while removing the block ice from ice cans for customer delivery.

Description	Value	Unit
Average Monthly Electricity Consumption	36,950	kWh
Average Electricity Charge	8.00	INR/ Unit
Latent heat of Ice (Constant)	80	kcal/kg
Cp water	1	kcal/kg/°C
Cp ice	0.5	kcal/kg/°C
Ice Plant Chiller compressor power	85	% of total Energy Consumption
Ice Plant Chiller compressor efficiency	88	%

Estimate

a) Energy consumption per tonne of ice 'output'

b) Total daily cooling load in kcals for freezing water into ice blocks

c) Refrigeration load on the chiller in TR (Tonne refrigeration) and

d) E.E.R. of ice plant chiller compressor.

The Management intends to pre-cool the inlet water from 30°C to 12°C using a separate water chiller drawing 0.8 kW/TR.

e) Find out the reduction in energy consumption per tonne of ice block output

f) % reduction in the condenser heat load of the plant chiller due to the use of pre-cooled water.

Assume absolute auxiliary energy consumption of the plant remains the same and only consider water chiller compressor energy consumption for estimating the savings.

Objective and Methodology

The objective of **Energy Management** is to achieve and maintain optimum energy procurement and utilisation, throughout the organization and:

- To minimise energy costs / waste without affecting production and quality
- To minimise environmental effects.

Energy conservation reduces the need for energy services and can result in increased environmental quality, national security, and higher savings. It is at the top of the sustainable energy hierarchy. It also lowers energy costs by preventing future resource depletion.

Energy conservation is the decision and practice of using less energy. Turning off the light when you leave the room, unplugging appliances when they're not in use and walking instead of driving are all examples of energy conservation.

Refrigeration may be defined as the process of achieving and maintaining a temperature below that of the surroundings, the aim being to freeze ice, cool some product, or space to the required temperature. The basis of modern refrigeration is the ability of liquids to absorb enormous quantities of heat as they boil and evaporate. One of the important applications of refrigeration is in **ice plants**. Ice plant is used for producing refrigeration effect which uses the vapour compression cycle and by using this cycle we are doing Performance Analysis of Ice Plant.

Step 1:

Monthly energy consumption = 36950 kWh
Daily energy consumption = (36950 / 30) = 1231.67 kWh
Energy consumption per tonne of ice delivered = (1231.67 / 15)
= 82.11 kWh/Ton

We know that specific weight of water = 1000 Kg/m3
Quantity of water input for the production 16.5 m3 =(16.5m3 X 1000kg/m3)
=16500 kg

Total cooling load per day

$$Q = Q1 + Q2 + Q3$$

where,
Q1 = Heat removed from lowering temperature from 30°C to 0°C in kcals
Q2 = Latent heat removed in freezing water to ice at 0°C in kcals
Q3 = Heat removed for sub-cooling of ice from 0°C to -8°C in kcals

$$Q = (16{,}500 \times 1 \times (30-0)) + (16{,}500 \times 80) + \{16{,}500 \times 0.5 \times [0 - (-8)]\}$$
$$= 4{,}95{,}000 + 13{,}20{,}000 + 66{,}000 = 18{,}81{,}000$$

Total Daily Cooling Load = 18,81,000 kcals/day

Step 2:

We know that 1 Ton = 3024 Kcal/hr
Cooling effect in TR = {18,81,000/(24 X 3024)} = 25.92 TR
Cooling effect in watt = (25.92 X 3500) = 90720 watts

Energy saved due to precooling
= [16500 X 1 X (30-12)]
= 297000 kcal/day

Effective TR saved = {297000/(24 X 3024)} = 4.09 TR
Revised TR saved = (25.92-4.09) = 21.83 TR
Energy consumption of precooler = {(0.8 X 297000)/3024} = 78.57 kWh

Step 3:

Ice plant chiller consumption per day = (0.85 X 1231.67) =1046.92 kWh
Ice plant auxiliary consumption per day =(1231.67 – 1046.92)=184.75 kWh
Power consumption of the chiller = (1046.92 / 24) = 43.62 kW

Specific energy consumption ={(1046.92 / 24) / 25.92}=1.68 kW/TR
Input power to the ice plant compressor =(0.88 X 1.683)=1.48 kW/TR

E.E.R. ice plant chiller
={(3024)kcal/hr / (1.48X860)kcal/hr}
=2.376

Step 4:

Energy consumption in chiller compressor after precooling

= (21.83 X 1.68 X 24)

= 880.18 kWh

Total energy required for precooler, compressor, and auxiliaries

= (Energy consumption of pre-cooler + Energy consumption in chiller compressor after pre-cooling + Ice plant auxiliary consumption per day)

= (78.57 + 880.18 + 184.75)

= 1143.5 kWh

Reduction in energy consumption in KWh/Ton for ice delivered

= {(1231.67 – 1143.5) /15}

= 5.88 kWh/Ton

Step 5:

Evaporator heat load after pre-cooling = (21.83 X 3024)

= 66013.92 kcal/hr

Compressor heat load after pre-cooling = (21.83 X 1.48 X 860)

= 27785.224 kcal/hr

Total condenser load after pre-cooling = (66013.92+27785.224)

= 93799.144 kcal/hr

Initial compressor load =(25.92 X 3024)=78382.08 kcal/hr
Initial evaporator load =(25.92 X 1.48 X 860)=32990.97 kcal/hr
Total initial condenser load =(78382.08+32990.97)=111373.05 kcal/hr

Percentage reduction in ice plant condenser heat load
=[{(1,11,373.05 – 93799.144) / 1,11,373.05}X100]
= 15.78%

Graphs:

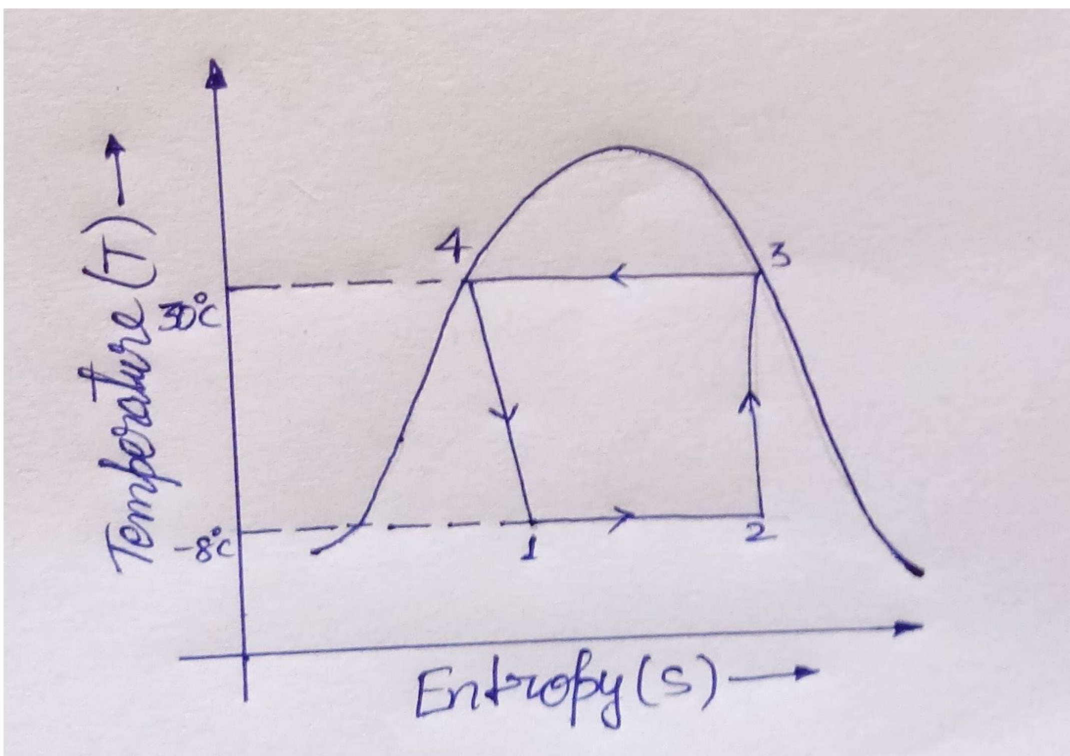

Figure-1: Temperature-Entropy(T-S) Diagram

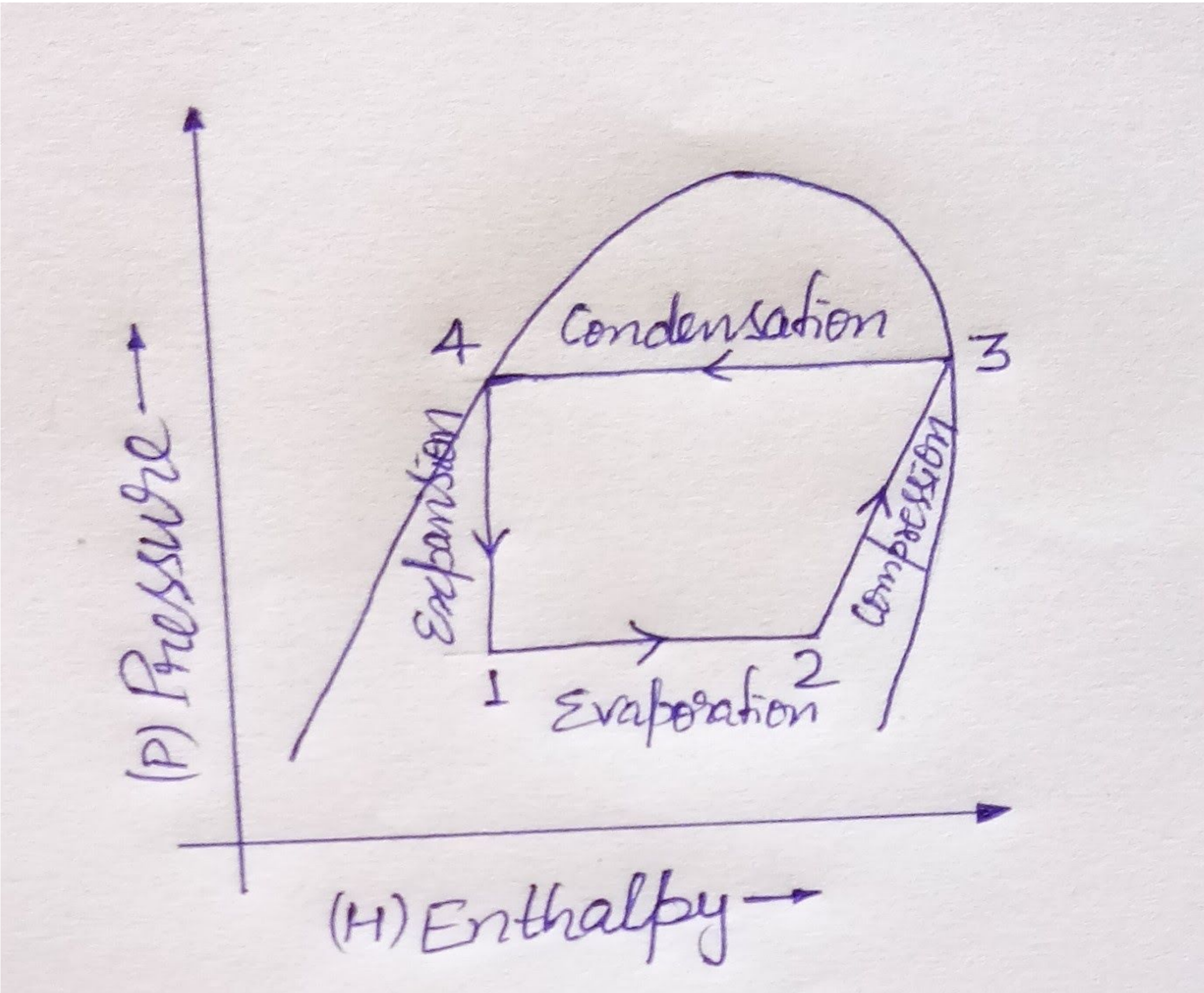

Figure-2: Pressure-Enthalpy(P-H) Diagram

References

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