OPTIMIZATION FOR ENERGY CONSUMPTION OF VAPOUR COMPRESSION REFRIGERATION SYSTEM IN DINSHAWS FOOD LIMITED, NAGPUR

N. Pathare[1] and R. Dhokne (Pathare)[2]
[1]Priyadarshani College of Engineering, Nagpur, MS, India
[2]Shri Shivaji Equation Society, Amravati's, Science College, Nagpur, MS, India
[1]pathare_nr@rediffmail.com,[2]raginidhokne@gmail.com

ABSTRACT

The aim of the project was to optimize the energyconsumption by compressor in Refrigeration systemat Dinshaws Dairy Food Ltd., Buttibori, Nagpur. When we surveyed the Industry, we found that thereis problem of more power consumption in compressor which leads to higher production cost. Detail study of the plant, its layout and during discussion with the plant manager, it found thatpower consumption of the plant was suspected to bemore. Detailed study of the plant, its layout was undertaken. Modification of the flow of the re frigerant was suggested. After suggestion, calculation of saving of the power consumption bythe refrigeration system was found to be 0.8575KW

Keywords: *Refrigeration, Vapour compressionsystem, Energy Consumption, Optimization*

Introduction

Dinshaws Dairy Food Ltd. is situated at Butibori, MIDC, Nagpur. An Ice Cream production plant is installed by YORK Company Ltd, Denmark. Their products are Carnivals, Family Packs, Candy(s), Cup's, etc. Dinshaws is one of the biggest ice cream producers in Asia. Their annual turnover is around Rs. 300 Crores. They have fully automated production plant. Whole refrigeration plant is controlled by PLC operated chamber.

Material and Method

The Refrigeration plant included the following components:

- Compressors
  - 3-HP Compressor
    (Rotary type screw compressors)
  - 11-Booster Compressor
    (Centrifugal compressors)
- Accumulator :
  Higher stage :- -33^0 C , +40^0 C
  Lower stage :- -7^{0}C
- Condenser:- Pre-heat Type
- Receiver :
  Diameter 1200mm, Length 6000mm
- Cooling Towers No.3
- Evaporators
- Tunnel : Spiral, Tray
- Cold Rooms
- Chillers
- Glycol Tank
- Refrigerant
  - Ammonia (Primary Refrigerant)
  - Brine (Secondary Refrigerant)Capacity of the plant:

100000 Litres /day - In summer season 50000 Litres /day - In winter season.

Ice cream manufacturing process: Process can be divided in the following steps:

1. Mixing	2. Pasteurization	3. Homogenization
4. Cooling	5. Ageing	6. Freezing
7. Filling / Packaging	8. Hardening	9. Storage and Distribution

Existing Ice–Cream Plant.

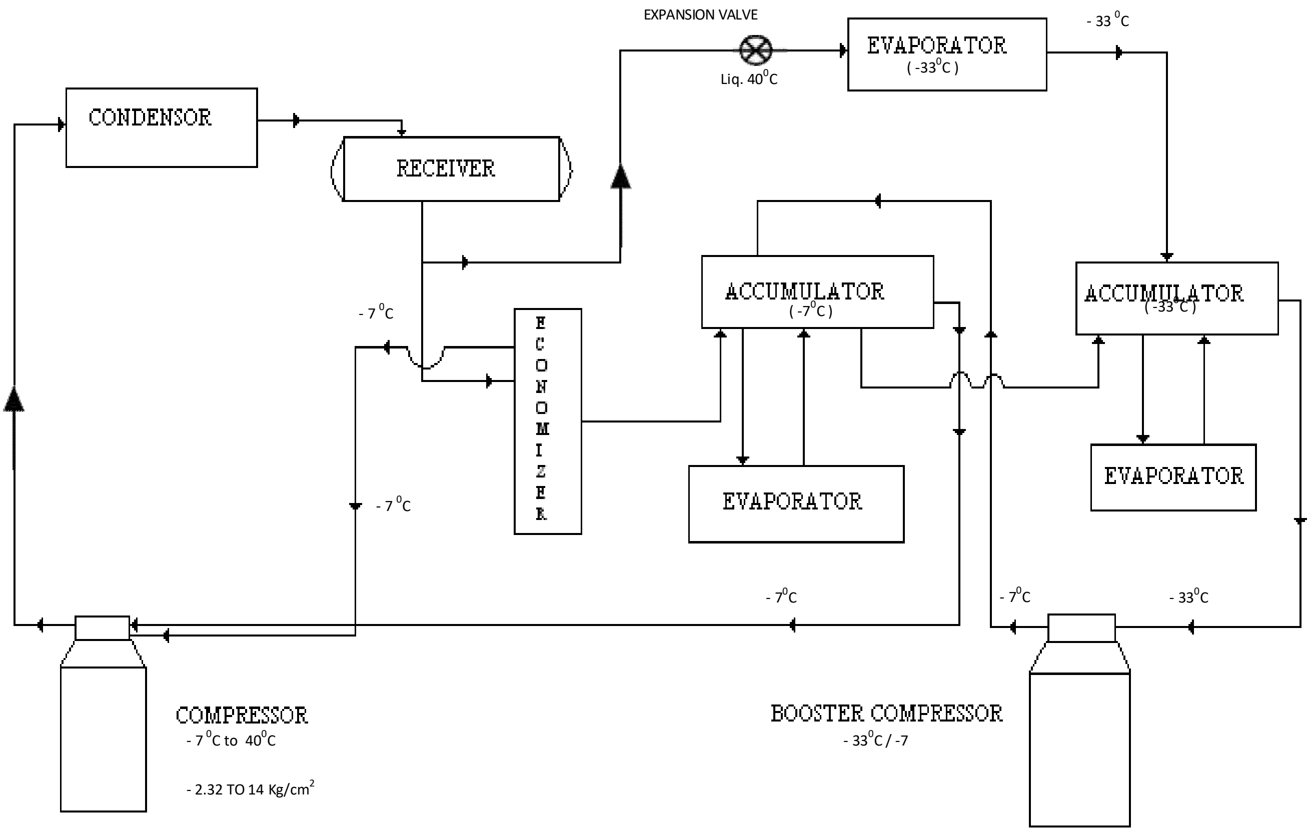

Fig.1 shows the flow diagram of refrigeration system for production of ice-cream. It consists of higher stage compressor, a booster compressor, condenser, receiver evaporator, two accumulators. The higher stage compressor is a rotary type screw compressor. The suction and discharge temperatures are -7^{0}C & +40^{0}C respectively. Second is a booster type centrifugal compressor whose suction & delivery temperatures are - 33^{0}C & -7^{0}C. It again consists of PHE condenser in which vapour refrigerant gives its latent heat to the surrounding medium. i.e. water which is circulated from a cooling tower. Vapour condensed and liquid refrigerant stored in a receiver. Refrigerant supplied to the evaporator continuously through the thermostatic expansion valve. In evaporator liquid refrigerant evapourates and takes its latent heat of vapour refrigerant from the surrounding medium which is generally brine (secondary refrigerant which takes part in actual cooling effect). After evaporation process vapour refrigerant collected in a accumulator, there are two accumulators maintained at -7^{0}C & -33^{0}C respectively. Accumulator is a device used for storage of refrigerant to supply the constant flowof vapour refrigerant to the compressor.

For each accumulator there is an evaporator which converts the refrigerant to the vapour for compressor, hence the cycle continues.

In this, booster compressors are connected to HP compressors such that as the load increases on the HP compressor one by one booster compressor get started. The load is in terms of temperature i.e. as the temperature in cold storage increases; compressor has to compress more refrigerant to get cooling effect.

Pressure Enthalpy & Temperature Entropy Diagram For Vapour Compr-ession Cycle

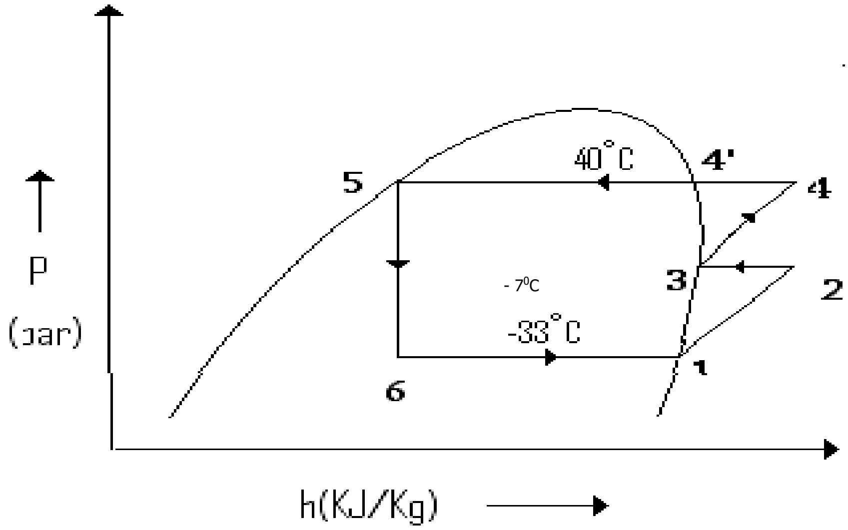

Fig.-2 – Pressure-Enthalpy Diagram Of Vapour Compression System (Existing)

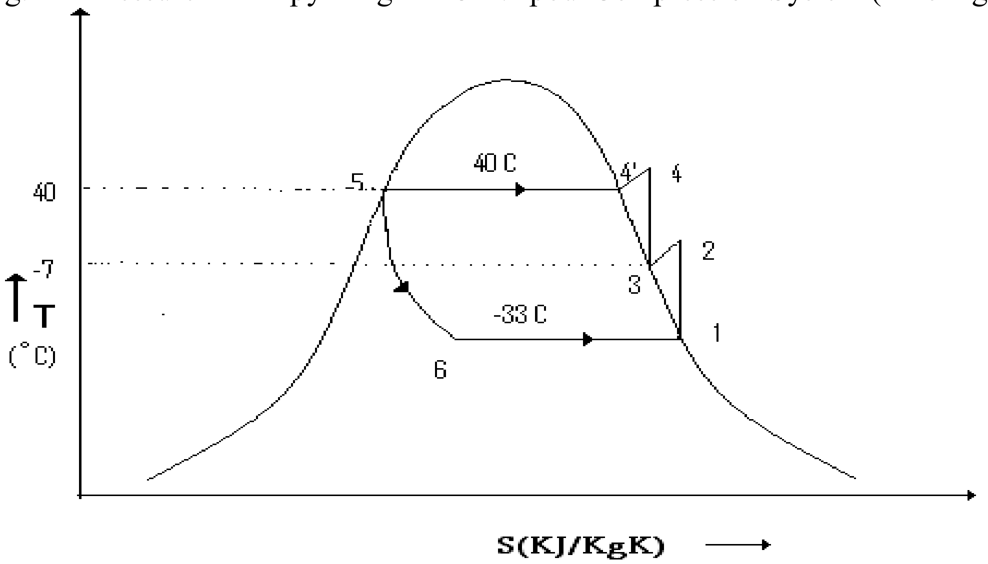

Fig.-3 – Temperature-Entropy Diagram of Vapour Compression System (Existing)

- Process 1 – 2: Compression process takes place isentropically. Vapour compress from -33^{0}C to -7^{0}C.
- Process 2 – 3: Desuperheating process take place vapour decreases the temperature & reachto dry saturated condition of temperature -7^{0}C.
- Process 3 – 4: At point 3 vapour enter in higher stage compressor and compress the refrigerant from temperature -7^{0}C to 40^{0}C.
- Process 4 – 4` : Desuper heating process takes place, vapours decreases the temperature & reach to dry saturated condition of temperature -7^{0}C.
- Process 4` – 5: Condensation process takes place, the superheated vapours enters the condenser, where heat is rejected at constant pressure, due to rejection of heat, the change of phase takes place. Latent heat removed and saturated liquid obtained at point 5.
- Process 5 – 6: Expansion process takes place and liquid refrigerant passed through expansion valve where liquid refrigerant throttle keeping the enthalpy constant and reducing the pressure. This wet vapour passes through evaporator at point 6, where it absorbs latent heat and convert it into saturated vapours and cycle is completed.
- Power required to drive the booster compressor is calculated 3.98KW and Second compressor is 4.38KW. So total power of the cycle is 8.36KW.
- Refrigeration effect of the system is 1029.5KJ/Kg.
- Mass flow rate of the refrigerant is 3.79Kg/min.

Modified Vapour Compression Refrigeration System

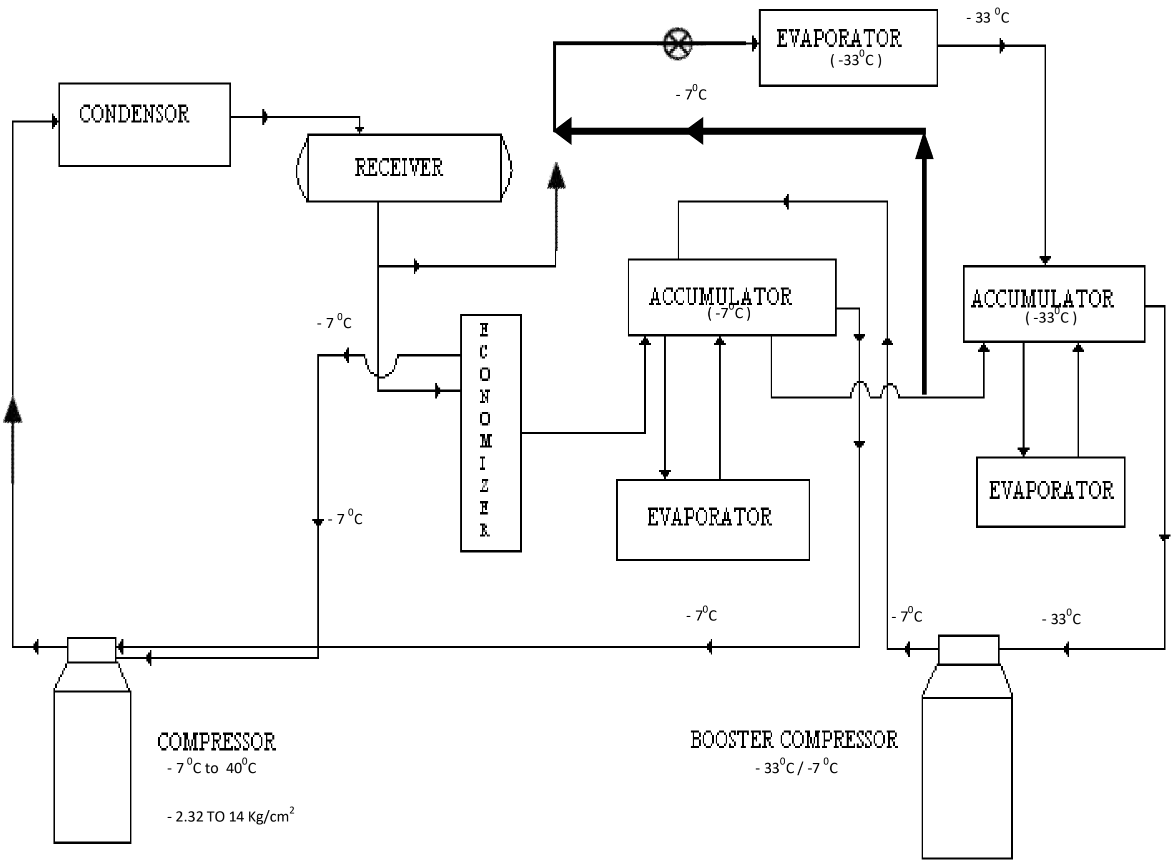

Fig. 4. Modified Flow diagram of vapour compression refrigeration system for production of Ice-cream

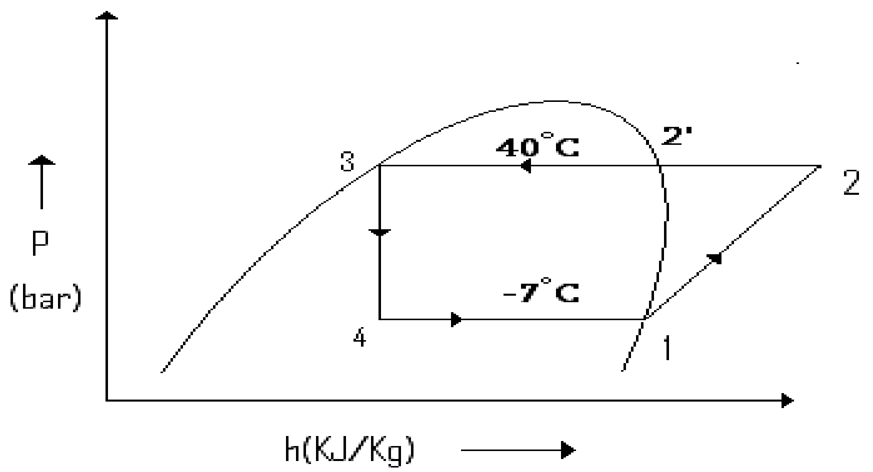

Fig.- 5 – Pressure-Enthalpy Diagram Of Vapour Compression System (Modified)

After studying the processes and operations carried out in the plant, the compressor is the major power consuming device. We studied the compressor suction and discharge temperature. We came to know that refrigerant has to travel from temperature range +40^{0}C to -33^{0}C for 65KW of refrigeration effect. As the suction temperature of compressor is -33^{0}C and discharge temperature +40^{0}C which consumed more power to drive the compressor so we thought that to change the inlet or outlet temperature ofcompressor. We found that there is a -7^{0}C vapour refrigerant is available in an accumulator. So we decided to give a -7^{0}C vapour refrigerant to the evaporator instead of +40^{0}C which reduce the load on a compressor. Now compressor compress the refrigerant from temperature - 33^{0}C to – 7^{0}C whichrequired less power than actual cycle.

Modified vapour compressor system work in two cycles which shown two different Pressure - Enthalpy & Temperature – Entropy diagram. As Shown in fig. 5, 7and fig. 6, 8. And according to these two cycles:-

1. Power required to drive the first compressor has calculated 4.237 KW and Second compressor is 3.28KW. So total power of the cycle is 7.51KW.
2. Refrigeration effect of the first system is 1063.25 KJ/Kg & second system is 1251.72 KJ/Kg.
3. Mass flow rate of the refrigerant in first systemis 3.66 Kg/min & second system is3.12Kg/min. Comparing the actual cycle compressor power andmodified cycle compressorpower, power saving is0.8575 KW and according to that, power saving in terms of rupees is

Power Saving In Terms Of Rupees:-

1 unit of Electricity = 1kWh
Rate/unit = 6 Rs. (Inclusive of All Taxes)Power saving = 0.8575kWh
Per day saving = 0.8575 × 24 = 20.58 KWh
Power Saving / year = 20.58 × 365= 7511.7KWh
Power saving in terms of money= 7511.7 × 6
Power saving in terms of money = 45070.2 Rs.
For Four Evaporator = 45070.2 × 4= **Rs. 180280.8**

4 Conclusions

After deep study of the flow diagram of refrigerant in Dinshaws Dairy Food Ltd . The power requirement for the existing refrigeration system was calculated. The calculations were also done by changing the path of refrigerant in the refrigeration cycle without changing the capacity of plant. It is found that the reduction of power consumption is around 1.0 KW. The saving in power increases the Coefficient Of Performance (COP) of the refrigerating plant.

The reduction in power consumption saves the electricity which ultimately increases company's profit. If the system will be modified by changing the refrigerant path in the cycle then the saving in the cost of electricity would be around Rs. 2 Lacs (Approx.) per annum which is an effective amount to improve company's profit.This project is being designed to reduce the power consumption of refrigeration system in Dinshaws Dairy Food Ltd. at Nagpur. The refrigeration system is studied and proposed work had found in the beginning. The power requirement for the existing refrigeration system was calculated. The calculations were also done by changing the pathof refrigerant in the refrigeration cycle without changing the capacity of plant. It is found that the reduction of power consumption is around 1.0 KW. The saving in power increases the Coefficient Of Performance (COP) of the refrigerating plant. The reduction in power consumption saves the electricity which ultimately increases company's profit. If the system will be modified by changing the refrigerant path in the cycle then the saving in the cost of electricity would be around Rs. 2 Lacs (Approx.) per annum which is an effective amount to improve company's profit.

References

1. C. P. Arora (2000). Refrigeration And Air Conditioning, Tata McGraw-Hill, New Delhi.
2. William C. Whitman & William M. Johnson Refrigeration And Air Conditioning Technology,Third Edition (1995), Delmar Publishers™ , United State Of America.
3. Frank Kreith, The CRC Hand Book Of Mechanical Engineering 1998 By CRC PressIncorporation.