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Design Considerations for a Cold Storage Unit

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ABSTRACT

Cold storages have enormous applications in real world. The main aim is to improve & extend the self-life. Especially in countries like India, it is observed that during peak season there is lot of production of vegetables & fruits whose cost comes down to a very low level, in fact sometimes it happens that they are thrown into dust bins due to unavailability of proper storage techniques at a viable cost. Further it is also observed that during off season, the prices shoot up & people face scarcity of the same fruits and vegetables. As the technology is developing in the field of refrigeration and air conditioning, remarkable comfort and saving are achieved. Maintaining the required low temperature for the common food we take will surely reduce the cost, as this process can be done at a time when the availability is plenty and the cost is low. In the current review, the design considerations for a cold storage unit using the refrigerant R134a is discussed.

Keywords : Commercially adaptive design, Cold storage room, Cold Storage Plant, Design of Cold Storage Unit.

I. INTRODUCTION

Refrigeration is a process in which work is done to move heat from one location to another. This work is traditionally done by mechanical work, but can also be done by magnetism, laser or other means. Refrigeration has many applications, including, but not limited to: household refrigerators, industrial freezers, cryogenics, air conditioning, and heat pumps.

The job of a refrigeration plant is to cool articles or substances down to, and maintain them at a temperature lower than the ambient temperature. Refrigeration can be defined as a process that removes heat. The oldest and most well-known among refrigerants are ice, water, and air. In the beginning, the sole purpose was to conserve food. The Chinese were the first to find out that ice increased the life and improved the taste of drinks and for centuries Eskimos have conserved food by freezing it.

II. METHODS AND MATERIAL

1. Importance of Refrigeration

The first mechanical refrigerators for the production of ice appeared around the year 1860. In 1880 the first ammonia compressors and insulated cold stores were put into use in the USA. Electricity began to play a part at the beginning of this century and mechanical refrigeration plants became common in some fields: e.g. breweries, slaughter-houses, fishery, ice production, for example. After the Second World War the development of small hermetic refrigeration compressors evolved and refrigerators and freezers began to take their place in the home. Today, these appliances are regarded as normal household necessities.

There are countless applications for refrigeration plants now. Examples are:

- Foodstuff conservation
- Process refrigeration
- Air conditioning plants
- Drying plants
- Fresh water installations
- Refrigerated containers
- Heat pumps
- Ice production
- Freeze-drying
- Transport refrigeration

In fact, it is difficult to imagine life without air conditioning, refrigeration and freezing – their impact on our existence is much greater than most people imagine.

2. Principles of Operation of A Cold Storage Room

The cold room like every other refrigerating system of the same magnitude employs the vapour compression method of mechanical refrigeration. Fig 3.1 presents the T-s diagram of the vapour compression cycle, while the Fig 3.2 illustrates the processes of the refrigeration employed in the cold room, respectively.

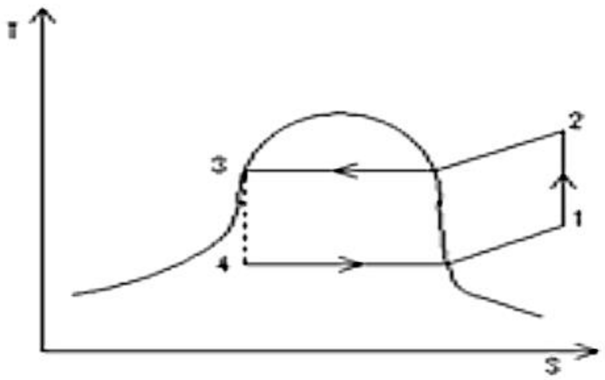

Figure 1 : Temperature-entropy diagram of the cold room storage cycle processes

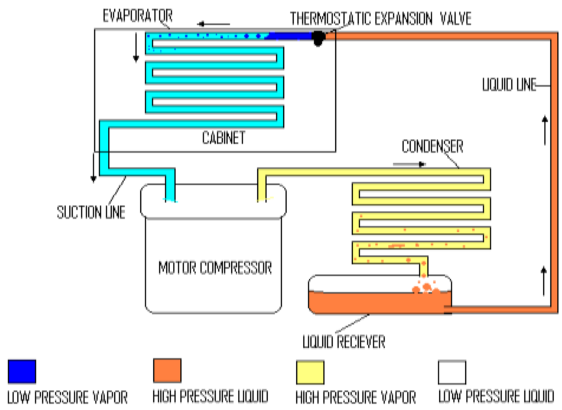

Figure 2 : Processes of refrigeration employed in the cold room

3. Refrigerant

3.1 Psychrometric Properties of the Refrigerant

The following values and parameters specified below were selected from the psychrometric chart of the refrigerant, R134a. Thus:

The Operating temperature range = -150C to 350C (258 to 308K);
Suction pressure, P1 = P4 = 343KPa;
Heat pressure, P2 = P3 = 958KPa;
Ratio of heat to suction pressure = 2.79;
Theoretical power = 0.68HP;
Discharge temperature = 140C (287K);
Boiling point = - 260C (247K);
Critical temperature = 1010C (374K);
Critical pressure = 4052KPa;
Liquid velocity = 0.505m/s;
Suction line velocity = 10.15m/s;
Discharge line velocity = 15.24m/s;
h1 = 233KJ/kg;
h2 = 256KJ/kg;
h3 = h4 = 93KJ/kg;
V1= 0.0624m^3/kg;
V2 = 0.0262m^3/kg;
V3 = 0.0037m^3/kg;
V4 =0.0094m^3/kg;
T1 = T4 = 100C (283K); and
T2 = T3 = 300C (303K), respectively.

3.2 Thermal Properties of the Refrigerant:

The thermal properties of the refrigerant, R134a at -15^{o}C according to Robert are as follows:
Thermal conductivity, K = 9.048 x 10^{-3} W/mK;
Dynamic viscosity, μ = 1.128 x 10^{-5} Kg/ms;
Kinematic viscosity, K = 0.85 x 10^{-6} m2/s;
Density of R134a vapour = 13.271Kg/m3; and
Prandtl number, Pr = 0.68, respectively.
Conversely, its thermal properties at 38^{o}C according to the same source are also:
Thermal conductively, K= 0.0824W/mK;
Dynamic viscosity, μ = 0.00202Kg/ms;
Kinematic viscosity, K = 2 x10-7 m^2/s;
Density, x = 1010Kg/m^3;
Velocity of liquid, V = 0.508m/s; and
Prandtl number, Pr = 3.25.

III. RESULTS AND DISCUSSION

1. Components & Refrigerant Proposed

i. **Compressor:** The compressor type selected is the hermetic reciprocating compressor of 1Hp capacity; operating between suction pressure of 343KPa and discharge pressure of 955KPa for the whole cold room system. With the control aid of a system of thermostat, the compressor is switched on or off automatically depending on the load requirement. The compressor was chosen considering the comparatively low specific volume of R134a, its large pressure differential and the ease of repair and servicing.

ii. **Evaporator:** The type of evaporator selected is a bare tube coil, forced connection, dry expansion; and made of aluminium material. It is forced connection because air is forced over the coil by a fan, to increase heat transfer rate as well as distributing the cooling effect evenly round the room. The bare tube is chosen because of its relatively low cost due to ease of construction.

iii. **Condenser:** The condenser selected is a base mounted, forced convection, air cooled condenser made of copper material. It lies on the same base with the compressor. With the aid of the thermostatic system, the air-blowing fan switches off when heat load is low and switches on when heat load is high. This helps the air in circulation cool the refrigerant efficiently.

iv. **Choice of Refrigerant:** The refrigerant, R134a was selected for the following reasons: It is an almost odourless liquid with a low boiling point of -260c at atmospheric pressure. It has low specific volume of vapor with a good volumetric efficiency. It is non-toxic, non-corrosive, non-irritating and non-flammable. Its ozone depletion potential is zero with a little global warming potential. More importantly, its cost is comparatively low, and it produces relatively good refrigerating effect at moderate and economical operating condition. Also, its leakage can be easily detected by soap solution.

2. Design Considerations

The important design considerations in the design of a cold storage include:

1. Heat Load Distribution
2. Cabinet Areas
3. Cabinet Volume
4. Heat Leakage load
5. Air Change Heat Load
6. Product Heat Load
7. Occupancy Heat Load
8. Total Heat Load
9. Compressor Design
   a. Work Done by the Compressor
   b. Mass Flow Rate of Refrigerant
   c. Compressor Capacity
   d. Refrigeration Effect
   e. Volume Flow Rate
   f. Coefficient of Performance
   g. Rated Power
10. Condenser Design
    a. Condenser Capacity
    b. Condenser Tube Diameter
    c. Surface Area of Condenser
    d. Length of the Condenser Tubes
    e. Condenser Performance
    f. Heat Rejection Factor
11. Evaporator Design
    a. Evaporator Capacity
    b. Evaporators' Tube Diameter
    c. Surface Area of Evaporator
    d. Length of Evaporator Tubes
    e. Evaporator Performance
12. Liquid Receiver Size

IV. CONCLUSION

A cold storage unit has to be designed keeping in mind, several parameters and above mentioned design considerations. Erroneous design of any of the parameters mentioned, would result in serious issues like cost inflation, less efficiency/ COP of the system, wastage of power etc. The climatic conditions in which the cold storage is to operate also plays a vital role in the selection of the material for the components and their design. In the current review, all the important design considerations of a cold storage unit are compiled.

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