EXPERIMENT 14 REFRIGERATION LOAD ESTIMATION OF A DAIRY PLANT

Structure

14.1 INTRODUCTION

Refrigeration is an essential utility required in a dairy plant for the preservation of milk and milk products and minimizing nutritional losses. The main dairy processes which need refrigeration in terms of chilled water or low temperature refrigerant include milk chilling & pasteurization, cold storage of all types. Raw and pasteurized milk are chilled and stored below 5° C for preserving its nutritive value and preventing growth of microbes present in it.

Refrigeration effect, in the form of chilled water or low pressure/temperature vapour, is generated by gas absorption or compression system. The latter one is more common in the dairy industry, in which high pressure/low temperature liquid refrigerant is expanded to result low temperature medium that can cool down to other medium by convection/conduction process. These chilled mediums are utilized for chilling milk in heat exchangers and/or evaporators of cold stores. The refrigerant after absorbing heat returns to compressors, where its heat value is enhanced for discarding in to atmosphere through condenser.

The refrigeration system consumes most of the electricity almost 40 to 45 % of total power requirement and hence, has direct impact over the operational cost and therefore, needs proper management.

Like steam, the extent of requirement of refrigeration depends upon process schedule and load of plant operations. During some period the requirement is higher compared to other period. Proper estimation of the refrigeration requirement ensures meeting of enough refrigeration for smooth plant operations. The information about the requirement of refrigeration is helpful in proper selection of the related equipment and would be significant in optimizing cost of utilities.

14.2 OBJECTIVES

ι   identification of refrigeration consuming and generating centres /processes; and

ι   load estimation of refrigeration for various processes /products & dairy plant.

14.3 EXPERIMENT

i.   Principle

Refrigeration is generated in refrigeration plant and utilized in milk chilling, pasteurization, cold store and deep fridges.

a.   Refrigeration requirement for milk chilling = Q1= Kcal =

Qty. of milk sp.heat (ambient temp, deg.C- 5 deg.C)

b.   Refrigeration requirement of milk pasteurization=Q2 Kacl=

Qty of pasteurized milk Sp.Heat of milk (Temp after Reg.- 5 deg.C)

c.   Cold space refrigeration requirement = Q3 Kcal=

Heat loss through walls, ceiling, loading/unloading window/door, heat gain by product stored and heat generated by electrical appliances and person working inside.

d.   Refrigeration produced by the system = Q Kcal/hour=

Refrigerant displaced/hour enthalpy of refrigerant at the entry and exit of evaporator or heat exchanging system.

Generally refrigeration load is expressed in terms of Tonnage of Refrigeration (TR), which is equivalent to heat required to melt 1 MT of ice at 0 deg.C in 24 hours. And hence it comes to 3333 Kcal /hour or 55.5 Kcal/minutes.

Note: Consider enough safety margin in each case on account of losses in distribution and heat transfer during the processing.

ii.   Requirements

i)   Plant Equipment: A dairy plant in operational condition having provision for generation & distribution of refrigerant and chilled water.

ii)   Instrument requirement

ι   Stopwatch, pressure and temperature gauges, flow meters or level indicators.

ι   Other accessories like graph paper, scale, pencil, eraser, refrigeration table .

iii.   Procedure

i)   Prepare a process diagram for each of products being manufactured in dairy and identify the various unit operation involved.

ii) Observe and record the operation period of each unit operation.

iii) Plot these hours on X –axis for each unit operations.

iv) Find out the refrigeration requirement of each operation on hourly basis.

v) Sum up refrigeration requirement of each operation on hourly basis.

vi) Plot the requirement of each process and overall requirement on Y-Axis.

vii) The graph will show requirement of refrigeration on hourly basis for the whole day. Mark the average, peak and lowest consumption rate/hour.

viii) Similarly observe the generation/supply ratings of refrigeration system and running period.

ix) Plot the rating on Y axis and running hours on the X-axis.

x) Compare the requirement and supply status.

xi) Arrive at conclusion to optimize the generation/supply of utility.

iv. Observations

Observe the followings and record:

Name of Process   Refrigeration Requirement Operation Period

1. Milk reception

    a. Milk procured

    b. Chilling periods

2. Milk pasteurization

    a. Processing qty., lit

    c. Pasteurization periods

3. Milk Product manufacturing & packing

    a. Milk products manufactured

    b. Product quantities & Refrigeration use/hour

    c. Manufacturing periods

4. Cold store particulars

    a. TR load of each cold store

    b. Operation hours of each cold store

5. Refrigeration Generation

    d. Capacity of refrigeration boiler

    e. Water consumption on hourly basis

    f. Fuel consumption on hourly basis

6. Refrigeration losses

    a. Refrigeration leakage points

    b. Chilled water leakage points

v. Results: Requirement of refrigeration in the dairy is as follows:

  a. Average hourly refrigeration consumption in dairy :

  b. Peak refrigeration requirement /hour: Period:

  c. Lowest refrigeration use /hour: Period:

  d. Processing consuming highest refrigeration: Period:

  e. Refrigeration generation/hour

     Total Running hours:

  f. Plot the refrigeration load on hourly basis as depicted in Fig-1:

Fig- 14.1 : Refrigeration Load Diagram

Use Hours ➤ 6-7-8-9-10-11-12-13-14-15-16-17-18-19-20-21-22-23-24-1-2-3-4-5

Refrigeration use:

⌄

ı Milk Chilling

ı Milk processing

ı Products manufacturing

ı Cold store -1

ı Cold store-2

ı Butter deep fridge

ı Ice cream deep fridge

ı Total refrigeration use

ı Total refrigeration generation
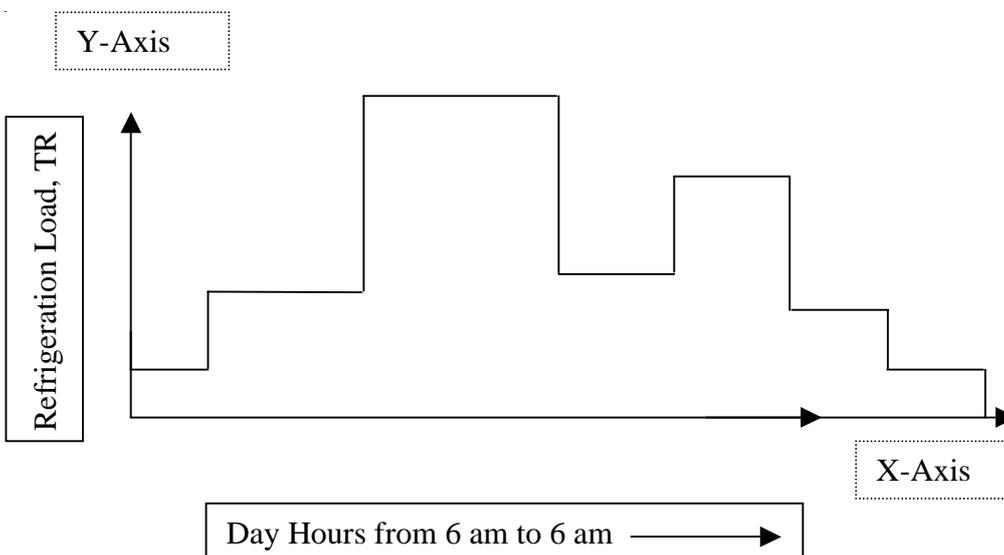
REFRIGERATION LOAD DIAGRAM

14.4   PRECAUTIONS

1. Refrigerant vapour and chilled water is used in composite manner for products/ processes and if, dairy do not have separate measuring device for each consumption centre, then it becomes very difficult to apportion the load and hence proper care in separating refrigeration use for each product is required.

2. Reschedule operations if present operation pattern is presenting very high peaks on some duration that affects meeting of temperature parameters.

3. Refrigeration effect produced is a function of condensing pressure and hence various factors affecting (air presence, improper water /air cooling, scaling of heat transfer surfaces) should be timely cared.