FOOD ENGINEERING

(Unit operations and process engineering)

Full Marks:- 100

Part A: Unit Operation:

1. ***Concept of unit operation:***

   a) Mass balance b) heat balance c) importance and examples of mass and heat balance in food processing operations.

2. Fluid flow:

   a) Fluid pressure: relation between absolute pressure, gauge pressure and vacuum, fundamental equation of hydrostatics, measurement of pressure difference, manometers.

b) Steady Fluid Flow:

   Continuity equation, Bernoulli's equation and its application (at least two examples)

c) Flow patterns:

   Laminar and turbulent flow, Reynold number, flow measuring equipments (venturi meter, orifice meters pitot tube and rotameters)

d) Flow of Fluids in tubes:

   concept of viscocity , Newtonian and non- Newtonian fluids, velocity profile, friction factors (Fannin;s and Darcy) use of Moody's diagram.

e) Head Losses:

   Head losses in tube flow, head loss in bends joint expansion, joint contractions, valves, loss coefficient s.

f) Transportation of fluids:

   Structure and working principle of centrifugal and gear pumps, selecting of pumps.

3. Heat transfer:

   a) Conduction: Fourier's law, thermal conductivities, heat transfer through a slab and cylinder, resistances in series, Introduction to unsteady state conduction, thermal diffusivities, Biot and fourier numbers.

   b) Convection:

Natural and forced convection ,surface heat transfer coefficients, overall heat transfer coefficient , dimensionless numbers and their applications , heat transfer through boiling liquids and condensing vapours .(Introduction only)

c) Heat Exchangers:

Shell and tube heat exchanges (single shell pass and multi tube passes) LMTD, NTU, NTU analysis , parallel flow and counter flow heat exchanges, fouling factors, plate heat exchanger, design of shell and tube exchangers.

4. Evaporation:

Boiling point elevation, structure and working principle of central circulating evaporators, climbing and falling film evaporators, mass balance, heat balance relation between feed temperature and live steam consumed, single effect and multi-effect evaporation , accessories of an evaporator.

5. Distillation:

a) Vapour -liquid relationship, Rault's law, boiling point diagram(t-x-y graph and x-y graph) of binary mixtures 3

b) Batch distillation 2

c) Rectification: rectification column, and its accessories (condensers, reboilers etc working principle of rectification column, equation of operating lines, effect of feed temperature, calculation of ideal plate numbers(McCabe-Theile diagram, Lewis method , minimum reflux method) calculation of column meter 6

6. Drying:

a) Psychrometry: dry bulb and wet bulb temperatures humidity and relative humidity, dew point specify weight and specific volume, enthalpy, application of psychrometric chart in drying.

b) Mass balance, equilibrium moisture, critical moisture, drying curve, drying rate curve, calculation of drying rate and drying time, The drying models (characteristic drying curve and moisture diffusivity)

c) Dryers: Tray dryer, tunnel dryer, drum dryer, spray dryer, fluidized bed dryers, uses of dryers in food industry.

7. Crystallization:

Basic principle of crystallization , super solubility , nucleation and growth rate, factors affecting the growth rate, mass balance, energy balance draff- tube baffle and vacuum crystallizers.

8. Separation techniques:

a) Filtration: Theory of filtration, constant rate and constant volume filtration, plate and frame filter press and its design, rotary vacuum filter.

b) Sedimentation: Terminal velocity, drag coefficient free and hindered setting thickners (working principle and design of thickner). Centrifugal separation, working principle of centrifugal separator and its application in industry. (cream separator as an example.

9. Size Reduction:

   Rittinger, Kick and Bond's laws, equipments for size reduction (Jaw crusher, Gyratory crushers, roll crushers, hammer mill, pin and disk mill, ball mill)

   Sieve analysis, standard sieves, particle size and its distribution, cut off diameter, fineness modulus, uniformity index 6

10. Mixing:

    a) Homogeneity of mixing, mechanism of mixing rate of mixing, energy consuption. 2

    b) Liquid-liquid, solid-liquid and solid-solid mixing homogenization (example: homogenizer in dairy industries) 2

11. Conveying:

    Introduction to belt conveyer, bucket elevator, screw conveyer, pneumatic conveyor and their application in food industries. 2

PART B: Process Engineering:

12. Process design development: 6

Design project procedure, types of designs, feasibility survey, process development design, construction and operation, flow diagrams, the preliminary design , equipment design and selection economics, comparison of different processes, equipment design and specifications, scale-up in design, safety factors.

13. General design considerations: 4

14. General design considerations:

Optimum design and design design strategy: 20

General procedure for determining optimum conditions, comparison of graphical and analytical methods, break even chart for production schedule and its significances for optimum analysis optimum conditions in cyclic operations . Accuracy and sensitivity of results (heat transfer and mass transfer) The strategy of linearization for optimization analysis, other mathematical techniques and strategies for establishing optimum conditions.

Practical:

1. Mass and energy balance: evaporation, distillation, and drying
2. Determination of Newtonian viscosity using Canon Fenske capillary viscometer, tube flow viscometer and Brookfield viscometer.
3. Determination of Reynold's number using tube flow viscometer.
4. Measurement of outflow using venturimeter, offficemeter, Vane and hot wire anemometer.
5. Determination of thermal conductivity, thermal diffusivity and specific heat capacity of food materials .Determine surface heat transfer coefficient through unsteady 9lumped method) heat transfer.
6. a) Comparative of counter current and parallel heat exchangers. Determine overall heat transfer coefficient and LMTD of the exchange system.

   b) Study of plate heat exchanger .Study of central circulation, climbing and falling film evaporators. Study of boiling point elevation.
7. a) Determination of ideal plate (column) numbers by Lewis and McCabe Thiele method.

   b) Study of rectification column.
8. a) Drying of grains, correlation between temperature ratio and time.

   b) Determination of characteristic drying and drying rate curve foe pasty foods.

   c) Production SMP & WMP in a pilot scale dryer and determination of (%) product recovery.
9. Study of constant rate and constant pressure filtration in a plate and frame filter press.
10. Study of centrifugal separators (cream separator) separation efficiency.
11. Determination of terminal velocity and drag coefficient during unhindered setting.
12. Study of pin and disk, hammer and roller mills. Particle size distribution.
13. Study of belt, chain, screw, bucket and pneumatic conveyers.
14. Layout of food plants.
15. Construction and establishment of food plants (Project work)

Text Books:

1. McCabe, W.L Smith,J.C, and Hariot ,P.Unit operations of chemical engineering.
2. Geankophis, C.J Transport Processes and Unit Operations.
3. Toledo, R.T Fundamentals of Food Process Engineering
4. Rizvi, SSH, And Mittal, G.S Experimental Methods in Food Engineering
5. Heldman .D.R. and Singh, R.P Food Process Engineering, 3rd Edition
6. Sahay, K.M and Singh, K.K Unit operations of Agricultural Processing
7. Peters, M.S and Timmerhaus, K.D. Plant design and Economics for Chemical Engineering

8. Holman, J.P. Heat Transfer