### DAIRY ENGINEERING

#### Course Contents

**DAIRY ENGINEERING**

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**PRE-REQUISITE COURSES**

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Objective
To disseminate the knowledge of properties of products and unit operations involved in dairy and food engineering

Theory
UNIT I
Engineering properties of dairy and food materials and their significance in equipment design; processing and handling of dairy and food products.

UNIT II
Concept of rheology: ideal elastic, plastic and viscous behaviour, viscoelasticity, rheological models and constitutive equations, Maxwell model, Kelvin model and Burgers model, viscoelastic characterisation of materials, stress-strain behaviour, creep, stress relaxation, non-Newtonian fluids and viscometry.

UNIT III
Rheology and texture of food materials: methods of texture evaluation, subjective and objective measurements, mechanical tests, firmness, hardness, dynamic hardness, objective methods of measuring texture, rheological properties of dairy products, strength of food materials.

UNIT IV
Aerodynamic and hydrodynamic characteristics: drag coefficient, terminal velocity and Reynold's number, application of aerodynamic properties to the separation, pneumatic handling and conveying of foods.

UNIT V
Design of single and multi-effect evaporators: design of spray dryer and its components, separation and recovery of dried product, design of recovery system, selection and design of auxiliary equipment.

Suggested Readings
DE 612

**HEAT TRANSFER**

**3+0**

**Objective**
To develop competence in Heat Transfer Analysis.

**Theory**

**UNIT I**
One-dimensional steady state heat conduction through fins (Extended surfaces): actual and approximate solution. Efficiency, effectiveness and design of profile area of fins.

**UNIT II**
Two-dimensional steady state heat conduction: analytical and numerical solution.

**UNIT III**
Unsteady state heat conduction: analytical solution.

**UNIT IV**
Forced convection heat transfer in flow over a flat surface: hydrodynamic and thermal boundary layer, continuity equation, momentum equation and energy equation, heat transfer coefficient/ Nusselt number in laminar and turbulent region of boundary layer. Stanton number; Coulburn Analogy; Empirical co-relations.

**UNIT V**
Forced convection heat transfer in flow through tubes: Nusselt number in the entrance region and fully developed laminar and turbulent region.

**UNIT VI**
Condensation and Boiling Heat transfer: Film wise condensation on vertical surface; Nusselt equation, Boiling liquids.

**UNIT VII**

**Suggested Readings**

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DE 613

**TRANSPORT PHENOMENA**

**2+0**

**Objective**
To develop competence in momentum, energy and mass transfer analysis.
Theory
UNIT I
Introduction to transport phenomena – Molecular transport mechanism, transport properties and their proportionality constants in momentum, energy and mass transfer.
UNIT II
Steady-state equations - Momentum transport equations for Newtonian and non-Newtonian fluids, continuity equation in different co-ordinates.
UNIT III
Equations of motion - Navier–Stokes equations and their application in viscous fluid flow between parallel plates and through pipes.
UNIT IV
Turbulent transport mechanism -- Mathematical analysis; eddy viscosity and eddy diffusivity; velocity, temperature and concentration distribution; time smoothing equations. Inter-phase transport in isothermal system -friction factors for various geometries.
UNIT V
Mass transfer -- Fick’s law of diffusion, diffusion of gases and liquids through solids, equimodal diffusion, isothermal evaporation of water into air, mass transfer coefficients.
UNIT VI
Dimentional analysis – Buckingham Pi-theorem and matrix method, application to transport phenomena, analysis among mass, heat and momentum transfer, Reynolds’ analogy.
UNIT VII
Boundary layer concept - Theoretical and exact solutions for heat, mass and momentum transfer.

Suggested Readings

DE 614 REFRIGERATION ENGINEERING 2+1

Objective
To impart knowledge of design, construction, operation, control and maintenance of commercial refrigeration systems: cold storages and Air conditioning plants.

Theory
UNIT I
Vapour compression refrigeration system: major components and their different types; theoretical vapour compression cycle, theoretical COP; Effect of operating parameters on COP; actual vapour compression cycle; multi-pressure commercial refrigeration systems.

UNIT II
Vapour absorption refrigeration system: Ammonia-Water system, Vapour absorption refrigeration cycle and its representation on Enthalpycomposition diagram; Absorption system calculations.

UNIT III
Heat Pumps: different ‘heat pump circuits’; analysis of heat pump cycle; Use of heat pumps in dairy plant for energy conservation.

UNIT IV
Non-conventional refrigeration systems: Thermo electric refrigeration, vortex tube, cooling by adiabatic demagnetization.

UNIT V
Design elements of Refrigeration equipments: compressor condenser, evaporator, cooling tower, spray pond etc. Balancing of different components.

UNIT VI
Design of cold storage and air-conditioning systems: types of cooling loads and their calculation, design of cold storage for food products, construction of cold storage, equipment selection, insulating materials, vapour barriers, Ice bank tank.

UNIT VII
Control and maintenance of a commercial refrigeration plant: Pressure regulating valves, Thermostatic valves, LP/ HP cutouts, high to low side bypass valve, condenser water regulating valve, capacity control devices, pump down control, defrosting methods, liquid charging; General preventive maintenance of refrigeration plant.

Practical
• To find and compare the theoretical and actual COP of a small refrigeration unit on Refrigeration Tutor.
• Study and design of refrigeration components of a bulk milk chiller
• Visit to a commercial refrigeration plant for cold storage/ ice bank unit and calculation of its theoretical COP by making cycle on P-h chart.
• Calculation of theoretical work and comparing it with actual work for some specified cooling job in a commercial plant.
• Study of various control and safety devices in a commercial refrigeration plant.
• Design problems on cold storage for different food/ dairy products.
• Use of Computer software specific to cold store AC design.
• Study the working of an actual heat pump system.

Suggested Readings
DE 615 DESIGN OF PROCESS EQUIPMENT 3+0

Objective
To provide basic knowledge of various procedures for the design of dairy equipment.

Theory
UNIT I
Design of vessels: codes and regulations, design for pressure and temperature, loading; allowable stress, minimum thickness after forming, corrosion mechanism, corrosion control, design for internal and external pressure, cylindrical and spherical shells, formed heads, reinforcement openings, fabrication requirements, inspection, tests and non-destructive examination, pressure tests, design and stress evaluation.

UNIT II
Design of milk storage tank: horizontal and vertical silos, insulated and uninsulated, nozzles and mountings.

UNIT III
High-pressure vessels: constructional features, material for high pressure, multi shell construction, solid walled vessel.

UNIT IV
Supports for vessel: bracket support, leg support, skirt support, saddle support.

UNIT V
Heat exchangers: shell and tube heat exchangers, construction codes, general design considerations, U- tube heat exchangers, double pipe exchanger, scraped surface exchanger, spiral tube exchangers, joints; welded tube joints, baffles and tube bundles, tube sheet, double tube sheet construction, plate type heat exchanger; air cooled heat exchangers. Computer software for design of heat exchanger.

UNIT VI
Design of reactor vessel: material of construction, agitation, classification, heating systems, design consideration tank coils.

Suggested Readings

DE 621 DAIRY AND FOOD ENGINEERING-II 3+0

Objective
To develop competence in shelf life simulation of dairy products.

Theory
UNIT I
Water activity and states: a thermodynamic quantity, water sorption isotherms, hysteresis, theories of sorption hysteresis, water activity measurement methods, water binding, control of water activity and moisture, principles of IMF and their application.

UNIT II
Permeability and shelf-life: theoretical considerations, permeability to gases and vapours, measurement methods, permeability of multiplayer materials, permeability in relation to packaging requirements of food products.

UNIT III
Calculation of shelf life and requirements for packaging, deteriorative reactions, accelerated testing, relationship between transport properties of the package and shelf life of packaged products, simulation of product package- environment interaction, shelf life simulation for moisture, oxygen and light sensitive products.

UNIT IV
Theory of ultra filtration and reverse osmosis, selection and types of membrane and properties concentration polarization, mathematical description of flow through membrane, application and use in dairy industry.

UNIT V
Microwave energy absorption, physical parameters in microwave heating processes, heat transfer phenomena, equipment and application in dairy food industry.

Suggested Reading

DE 622 BIO-THERMAL PROCESS ENGINEERING 3+0

Objective
To teach the students on biological processes associated with food and dairy industries.

Theory
UNIT I
Introduction to biochemical engineering: Biochemical kinetics, kinetics of substrate utilization, enzyme reaction, growth of microorganisms, fermentors, pasteurization and sterilization and thermal destruction.

UNIT II
Design and analysis of fermentation vessels: residence time distribution, reactors in food processing, reactor types, analysis of reactor systems.

UNIT III

UNIT IV
UHT systems and recent advances: factors affecting spoilage of food, Aseptic packaging systems and conditions.

UNIT V
Thermo-bacteriology: Survivor curve, thermal death curve, Arrheneous curve, techniques for determination of heat resistance of micro organisms, analysis of thermal resistance data, processing in containers, process time, lethality, design of batch and continuous sterilisation cycles in vat.

Suggested Readings

DE 624 ENVIROMENTAL ENGINEERING 2+0
Objective
To disseminate the knowledge pertaining to waste treatment in dairy and food processing plants.

Theory
UNIT I
Waste water sources, characteristics, standards for disposal of dairy waste water.
UNIT II
Physical, chemical and biological characteristics of waste water, measurement of organic content in waste water.
UNIT III
Physical unit operations in waste water treatment: screening, racks, mixing, flocculation, sedimentation, floatation, elutriation, vacuum filtration & incineration.
UNIT IV
Chemical unit operations in waste water treatment: reaction kinetics, chemical precipitation, aeration and gas transfer process, rate of gas transfer, adsorption & disinfection.
UNIT V
Biological unit operations- aerobic and anaerobic cycles; kinetics of biological growth, application of kinetics to treatment systems, aerobic waste treatment, anaerobic waste treatment.
UNIT VI
Air conditioning systems: clean – room air conditioning; important pollutants of air; properties of particulate matter and air pollution control methods.

Suggested Readings

DE 625 INSTRUMENTATION AND PROCESS CONTROL 2+1

Objective
To impart basic knowledge on principles of measurements and process control, understanding the working and selection of instruments and devices for simple applications.

Theory
UNIT I
Instrument Terminology: Elements of generalized measurement system, static and dynamic characteristics of instruments.
UNIT II
Transducers: Electrical, mechanical, magnetic and optical transducers for measurement of process variables like temperature, pressure, flow, level, consistency, pH and humidity.
UNIT III
Indicating and Recording Devices: Digital indicators, strip and circular chart recorders.

UNIT IV
Principles of Automatic Process Control: Process characteristics, control system parameters, discontinuous, continuous and composite control modes. Final controlling elements, pneumatic and electric controllers.

UNIT V
Introduction to Computer Based Control: Computer based controller, data logging, supervisory control, flow chart, control system networks, basic structure and operation of programmable logic controllers (PLCs).

Practical
Study of various transducers for measurement of pressure, flow, level, humidity; temperature; study the controller and recorder of pasteurizer; the working of controllers in constant temperature water baths; to make ladder diagrams and flow sheet diagrams for control logics; to programme a PLC; computer interface of a PLC.

Suggested Readings

Pre-requisite Courses in Dairy Engineering for M. Tech. (DE) Students with B. Tech. (Dairy Technology) background

DE 412 STRENGTH OF MATERIALS 2+0

Objective
To develop competence in stress analysis of machine parts.

Theory
UNIT I
Review of stresses in machine parts, temperature stresses, principal planes and stresses, Mohar’s circle of stress.

UNIT II
Bending of beams, stress analysis in beams of two different materials, shear stresses in beams.

UNIT III
Strain energy in tension, compression, shear, bending and torsion. Impact loads on tension members, strength of biomaterials.

Suggested Readings
Objective
To provide basic knowledge of construction and operation of various machine tools and metal cutting.

Theory
UNIT I
Principles of metal cutting: Geometry of single point cutting tools, drills and milling cutters, normal and effective rake, chip formation, shear plane and shear zone analysis. Cutting tool materials heating of tools and use of cutting fluids.
UNIT II
Types of grinding machines, grinding wheels, their selection, speed, and wheel materials, shaper and planer machines.
UNIT III
Types of lathe machines and lathe operations, Turret and Capstan lathes, lathe tools, types of milling machines, milling cutters, cutting speed, calculation of milling time.
UNIT IV
Types of drills and drilling machines, sawing machines, abrasive cutting, power hacksaw, speed and feed for drilling, shaping, milling and lathe operations.

Practical
Lathe operations such as facing, turning, taper turning and thread cutting, Use of radial drilling machine. Study the construction and operation of milling machine, plain milling on milling machine. Study the operation of a shaper and prepare a square job from a given round bar.

Suggested Readings
Theory
UNIT I
Engineering properties of biological materials – Mechanical, electrical and thermal properties; aerodynamic characteristics and frictional properties; application of engineering properties in design and operation of processing equipment.
UNIT II
Handling of food products – Mechanics of bulk solids, selection of bulk handling equipment, operation and construction of conveyors and elevators.
UNIT III
Mechanical cleaning and sizing of food products – Size reduction, size characteristics, particle geometry, energy for size reduction of granular materials and dry powders, size-reduction equipment, performance characteristics of size reducers.
UNIT IV
Crystallization – Material and energy balance in crystallizers, principles of crystal growth, super saturation and nuclei formation, operation of batch and continuous crystallizers.
UNIT V
Distillation – Flash distillation of binary mixtures, differential distillation, steam distillation.
UNIT VI
Flow through porous media -- Absorption, extraction and extrusion operations.

Suggested Readings

DE-411 MATERIAL SCIENCE
(2+0)

Objectives: - To provide basic knowledge about the basic structure of material and their change in mechanical properties as a result of operation of various heat treatment processes.

THEORY

Unit I
Structure of atoms and molecules, Binding in solids, Types of bonds, Covalent, Ionic, metallic and molecular binding. Defects or imperfections and dislocations, Solid solutions and characteristics of solid solutions, inter-metallic compounds.

Unit II
Engineering requirement of materials such as Properties of materials such as mechanical, Thermal and Technological etc. Mechanical properties – Tensile strength, yield strength, creep, impact strength. Technological properties – Hardness, Weld-ability, Machinability, formability, Castability etc.

Unit III
Deformation of metals; elastic and plastic deformation, theory (dislocation) Bauschinger effect, work hardening, recovery, recrystallisation and grain growth, cold and hot working. Effect of grain size, heat treatment, atmospheric exposure and low temperature on the properties of metal.
Unit IV

Heat treatment, Necessity of heat treatment processes, Microstructure of carbon steel, behaviour of steel when heated, critical points, Fe-C equilibrium diagrams, Critical cooling rate, Different heat treatment such as stress relieving, annealing, normalizing, hardening, tempering, case hardening, surface hardening etc. factors affecting harden ability, martensitic transformation, alloy steels, effect of alloying element on structure, mechanical properties and heat treatment.

REFERENCE BOOKS