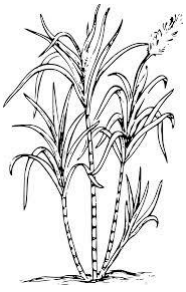
UNIVERSITY OF MYSORE

M.Sc. SUGAR TECHNOLOGY SYLABI

CHOICE BASED CREDIT SYSTEM

2013-14



DEPARTMENT OF SUGAR TECHNOLOGY

Sir M Visvesvaraya Post Graduate Centre

Tubinakere, Mandya, Karnataka, India – 571 402

Preamble

Endeavoring to serve the needs of Sugar Industry, the University of Mysore is offering M.Sc Sugar Technology program since 1993. The curriculum is based on the Associateship in Sugar Technology (ANSI) of National Sugar Institute, Kanpur, UP (Ministry of Consumer Affairs, GOI). Under the CBCS scheme the student has to acquire 76 credits for the successful completion of the master's program. The students undergo academic work for 3 terms in the department followed by 1 term internship/in-plant training in a sugar factory.

- The student has to acquire 4 credits during 2nd semester by opting open electives offered in other P.G Departments or Institutes under jurisdiction of the Mysore University
- The student can opt for additional courses/electives which will be considered as 'Add on Course' for which additional credits will be awarded
- The student has to undergo internship/in-plant training in a Sugar Factory (Crushing Season) during 4th semester (January to May) and submit a report in the prescribed format.
- The internal assessment for self study electives during the internship will be based on submission of assignments by post or e mail at prescribed intervals
- The C1 & C2 assessment is compulsory and pattern of assessment involves Tests, Assignment & Seminar by the subject teacher.
- 1 Credit is equivalent to; 1hr of Lecture Class (L) or 2hr of tutorial (T) or 2 hr of Practical Class (P)
- Following is the Credit Pattern of the M.Sc Course

Semester	**I**	**II**	**III**	**IV**
Hard Core	10	14	17	06
Soft Core	09	06	06	--
Open Elective	--	04	--	--
Self Study Elective	--	--	--	04
Total Credits (76)	**19**	**24**	**23**	**10**

I SEMESTER

Hard Core	Credit (L:T:P)	Required
1. Sugar Processing - Clarification	3 (2:1:0)	10
2. Chemical Engineering – Heat & Momentum Transfer	3 (2:1:0)	
3. Sugar Technology Practical	2 (0:0:2)	
4. Chemistry Practical	2 (0:0:2)	
Soft Core (Choose 3)		
1. Sugar Engineering	3 (2:1:0)	3 X 3 = 9
2. Technical Chemistry	3 (2:1:0)	
3. Sugarcane Agriculture	3 (2:1:0)	
4. Sugar Chemistry	3 (2:1:0)	
5. Instrumental Methods of Analysis	3 (2:1:0)	
		Total 19

Sugar Processing - Clarification

Course: Hard Core, Credit: 03, Lecture: 02hr, Tutorial: 02hr, IA Marks: 30, Exam Marks: 70

Unit 1

Introduction: Brief account of Sugar Industry and Sugar Manufacturing Process Composition of Sugarcane and Juice, Importance of juice clarification, Weighing and metering of juice (Maxwell Boulogne Scale & Magnetic Flow Meters)

Juice Heating: Types of juice heater, construction & working of tubular heater, removal of condensate and non-condensable gases, vacuum equalization, scaling of tubes, cleaning & testing of heater, concept of vapor line & dynamic juice heater. Effect of heat on juice, Purpose of primary and secondary heating. Construction and working of Direct Contact Heater (DCH), Plate Heater (PHE), advantages & disadvantages.

Unit 2

Clarification: Techniques of clarification; Defecation, Sulphitation & Carbonation, clarificants used in Sugar Manufacture.

Lime; specification, storage - Preparation of milk of lime; rotary lime slacker, classifier, MOL tanks, lime pumps, use of hydrated lime powder.

Sulphur; specification & storage, production of sulphur dioxide gas - combustion of sulphur, construction & working of sulphur burner, film type sulphur burner.

Liming & Sulphitation; Effect of liming & sulphitation on cane juice, simultaneous liming & sulphitation.

Unit 3

Subsidation: Principle of subsidation, floc formation, flocculants, construction & working of Dorr clarifier, operation of Dorr, velocity of juice in clarifier, flash tank cleaning & maintenance of clarifier, juice & mud removal, preservation of juice during shut down, factors affecting clarification, relationship among pH – temperature - retention time, effect of cane quality on clarification, Short Retention Time Clarifier, construction & working, advantages & disadvantages.

Filtration: Importance, preparation of mud – mud mixer, **Vacuum filter**; construction and working, effect of washing on pol in cake, filtrate receivers, baby condenser, vacuum pump, filtrate clarification system, **Decanters**; construction, working, advantages & disadvantages.

Reference:

1. Principles of Sugar Technology Vol. I, - Peter Honig
2. Cane Sugar Handbook - D P Kulkarni
3. Handbook of Cane Sugar Technology – R B L Mathur.
4. Introduction to Cane Sugar Technology – G H Jenkins.
5. Hand Book of Cane Sugar Engineering – E Hugot
6. Introduction to Sugar Technology – Chen & Chou
7. Training Manual for Sugar Factories – Mangal Singh

Chemical Engineering – Heat & Momentum Transfer

Course: Hard Core, Credit: 03, Lecture: 02hr, Tutorial: 02hr, IA Marks: 30, Exam Marks: 70

Unit 1

Introduction: Elementary chemical engineering concepts, concept of unit operations, Heat transfer by Conduction, Convection and Radiation.

Conduction: Fourier's law, Steady state unidirectional heat flow through single and multiple layers, Cylinders

Convection: Individual & overall heat transfer coefficient, LMTD, forced and natural convection. Heat Transfer with Phase Change - Boiling phenomena, Nucleate and film boiling, Condensation – Film and Drop wise condensation, Nusselt's equations.

Heat Transfer Equipment: Shell and tube heat exchangers, condensers.

Radiation: Properties and definitions, Stefan – Boltzmann law, radiation involving gases and vapours, **Insulation**: Insulation materials, types of insulation, thickness of insulation.

Unit 2:

Fluid Statics: Concept of Momentum Transfer, Nature of fluids and pressure concept, Variation of pressure with height – hydrostatic equilibrium, Barometric equation, Measurement of fluid pressure – manometers.

Fluid flow: Types of fluids –Viscosity of gases and liquids. Types of flow – laminar and turbulent flow, Reynolds number. Basic equations of fluid flow: Average velocity, Mass velocity, Continuity equation, Euler and Bernoulli equations, Flow of incompressible fluids-Laminar flow through circular conduits. Turbulent flow in pipes, friction factor

Transportation of fluids: pumps – positive displacement and centrifugal pumps. Fans, compressor and blowers. Metering of fluids - Pipes, Fitting and valves, measurement of liquid and gas flow rates by orifice meter, venturimeter, rotameter and pitot tube.

Reference:

1. Chemical Engineering, Vol I - Coulson & Richardson.
2. Unit Operations of Chemical Engineering – Mcabe, Smith & Harriot
3. Principles of Unit Operations - A S Foust, L A Wenzel, CW Clump
4. Introduction to Chemical Engineering - Walter L Badger & Julius T Banchero
5. Unit operation in Cane Sugar Production – John H. Payne
6. Chemical Engineers' Handbook, Perry & Green, McGraw Hill, 1997

Sugar Engineering

Course: Soft Core, Credit: 03, Lecture: 02hr, Tutorial: 02hr, IA Marks: 30, Exam Marks: 70

Unit 1: **Extraction of Juice**

Cane Preparatory Devices: Introduction**, s**tructure of cane, methods of juice extraction, definition of technical terms, Sugarcane harvesting – manual & mechanical, advantages & disadvantages, cane handling equipments. Description of feeder table, cane carrier, kicker. Preparatory devices – knives, shredder, fibrizer, preparatory index. Cane carrier, donnely chute, pressure feeders. .

Mills: Type, construction of mills, headstock, pinion, roller, power for milling, crushing of cane in mills, imbibition- its importance, hydraulic pressure system, grooving of roller, lotus rollers, trash plate, mill drives (Electric & Hydraulic), auto setting mill, performance of mills, primary & secondary extraction, calculation of mill settings, mill sanitation.

Diffuser: Principle of diffusion, cane & bagasse diffusion, construction & working of diffusers, comparison with milling, sugar beet diffusers.

Unit 2: **Steam & Electricity Generation**

Boiler: Fuels, characteristics of bagasse, characteristics of bagasse combustion, formation of steam, types of steam. Construction of water tube boilers, mountings & accessories, furnaces (Spreader Stroker & Travelling Grate), Boiler operation – blow down, furnace cleaning, Induced & forced draught. Description of Super heater, Economiser, Air pre-heater, Electrostatic Precipitator, bagasse dryer. Feed water specification and treatment (Internal & External), DM & RO Plants, Boiler Instrumentation & Control.

Steam turbines: Classification – description & working of extraction & condensing type turbines, specific steam consumption.

Alternators: Generation of electricity, sugar factory requirements, alternators – size, type, efficiency, 3 phase AC generation, power transmission system.

References:

1. Hand Book of Cane Sugar Engineering - E Hugot
2. Boiler Operator's Guide – A L Kohan
3. Exposure to Boilers – G S Aglave
4. Boiler Operations- Murugai and Ramchandra
5. Modern Milling of Sugarcane – Francis Maxwell
6. Sugar Machinery – A J Wallis Tayler
7. The Efficient Use of Steam – Oliver Lyle
8. Machinery and Equipment – L A Tromp

Technical Chemistry

Course: Soft Core, Credit: 03, Lecture: 02hr, Tutorial: 02hr, IA Marks: 30, Exam Marks: 70

Unit 1

Carbohydrates - classification, structure, physical properties, reactions of glucose & fructose (with organic & inorganic reagents), alkaline, acidic & thermal decomposition

Sucrose: Structure, formation in plants & nutrition, physical properties (aqueous, optical, electrical), chemical properties (hydrolysis, oxidation, reduction, alkaline, acidic & thermal degradation), sucrose derivatives & uses, enzymic & polymerization products. Polysaccharides - cellulose, starch and dextran.

Crystallization: mechanism of crystal growth, rate of crystallisation (diffusion, viscosity, colloids, crystallographic considerations), crystallography of sucrose.

Unit 2

Nonsugars: Organic, inorganic, nitrogenous & non nitrogenous nonsugars in cane

Proteins & Amino acids: Distribution of Nitrogen in cane, classification & general properties, proteins & amino acids of sugarcane and their behavior during processing - maillard reaction, thermal decomposition, suppression of heat transfer etc.

Coloring Matter: Coloring matter present in sugarcane – chlorophyll, flavonoids, anthocyanins as colorants, coloring compounds developed in process – caramel, Hexose degradation products, maillard reaction products, Colorimetry

Color Removal: Theory of adsorption, adsorption of coloring matter, use of activated carbons. Ion Exchange Resins – theory, regeneration of resins, application in sugar industry

Unit 3

Laboratory Control & Analysis: Definitions & terminology, Sample collection – raw materials, sugar house products & by products, importance of laboratory control

Estimation of Solids: Estimation of solids by Brix Hydrometer, Refractometer & Drying

Estimation of Sugar: Optical activity, specific rotation of sugars, principle of polarimeter, international sugar scale, normal weight of sugar; determination of pol%, double polarization, clerget constant. Laurent polarimeter, industrial polarimeter, white lamp Single wedge/double/wedge polarimeter, automatic polarimeter. Estimation of Reducing Sugars

Reference:

1. Organic Chemistry - R.T. Morrison & R.N. Boyd.
2. Organic Chemistry Part 1 - I.L Finar.
3. An Introduction to Carbohydrate Chemistry – J.Haneymon and Guthrie
4. Text Book of Physical Chemistry- S.Glasstone.
5. Principles of Sugar Technology, Vol 1- P. Honig
6. Physical and Chemical Methods of Sugar Analysis – Brown & Zerban
7. Biochemistry – Voet & Voet

Sugarcane Agriculture

Course: Soft Core, Credit: 03, Lecture: 02hr, Tutorial: 02hr, IA Marks: 30, Exam Marks: 70

Unit 1

Introduction: Origen of Cane, cultivation in India, varieties**,** climatic conditions, sugarcane agro climatic zones in India. Sugarcane pricing and payment, cane as a bio-fuel.

Soil: Types, properties – Visual & morphological properties, analytical properties, fertility & soil problems, sustaining fertility, soil conservation practices,

Planting: Preparatory tillage, planting time, selection of seed cane, methods of planting - flat, ridges & furrows, trench, IISR 86206, ring, spaced transplanting & polybag seedling transplanting method.

Growth of Sugarcane: Germination, development of shoot & root - factors affecting, tillering, growth of leaves, internodes & stem, factors influencing cane growth, formation and storage of sugar in cane.

Unit 2

Irrigation: Water requirement, scheduling, method of irrigation – surface, overhead or sprinkler, drip irrigation, water quality, water logging, drainage – side, main & infield drains.

Manuring: Cane nutrition, functions of macro & micro (trace) nutrients, fertilizers – N, P, K, S, Ca & Mg carriers, Mixed or compound fertilizers, biofertlizers, foliar applications, fertigation, organic & green manuring, time & method of application, visual symptoms of nutrient deficiencies and disorders.

Weeds: Common weeds, aquatic weeds, losses due to weeds, methods of weed control – mechanical, manual, chemical (time, method & dosage), integrated weed management, measures to reduce the weeds.

Pests: Leaf eating & sucking insects**,** stalk attacking insects, root attacking insects, soil insects & Non insect species.

Diseases: Major diseases (red rot, smut, pineapple, mosaic, wilt etc), period of occurrence, control measures (chemical & biological), losses due to pests & diseases, plant protection measures.

Unit 3

Ripening: Methods of judging ripeness or maturity, factors affecting ripening, accelerating ripening and chemical ripeners.

Harvesting: Manual & mechanical harvesting of cane, transportation of cane, post harvest deterioration of sugarcane – causes, effect & losses, effect of extraneous matter (tops/trash) on processing, burning of cane.

Ratooning: Definition, yield & quality, number of ratoons, advantages and disadvantages, area and productivity, causes for low ratooning, tillering, verities for good ratoons, removal of compaction, gap filling, fertilizer application, water requirement.

Reference:

1. Sugarcane in Agriculture and Industry – Gururaj Hunsigi
2. Sugarcane – C N Babu
3. The Energy Cane Alternative – A G Alexander
4. Sugarcane Production Technology in India – R S Verma
5. Sugarcane Crop Management – S B Singh, G P Rao & S Eswaramurthy
6. Sugarcane Cultivation and Management – H Baker

Sugar Chemistry

Course: Soft Core, Credit: 03, Lecture: 02hr, Tutorial: 02hr, IA Marks: 30, Exam Marks: 70

Unit 1

Sucrose: Structure, physical & chemical properties, uses of sucrose; food applications, feedstock for chemical synthesis, fermentation feed stock, pharmaceutical applications, nutrition & health aspects and metabolism of sucrose.

Sugar Analysis; standards & definitions, physical methods of sugar analysis, Polarimetry, Refractive index, colorimetric methods, enzymatic methods, chromatographic methods, NIR, determination of other components; moisture, ash & inorganic constituents, particle size distribution, insoluble matter.

Unit 2

Sugar Derivatives: Ethers- Triethyl ethers, methyl ethers, other alkyl ethers, silyl ethers, cyclic acetals. Esters: Acetates, benzoates, pivalates, fatty acid esters, other carboxylic esters, sulphonate esters, deoxyhalogen derivatives, anhydrides & epoxides, nitrogen containing compounds, sulphur containing compounds, oxidation compounds from enzymic isomerization, polymeric intermediates.

Unit 3

Sugar Alcohols; Occurrence, Physical & chemical properties; anhydrization, esterification, etherification, acetal formation; oxidation, reduction, metal complexes, isomerization, analysis, manufacture of sorbitol, mannitol & xylitol.

Reference:

1. Encyclopedia of Chemical Technology, Kirk & Othmer, Vol – 4
2. Concise Encyclopedia of Chemical Technology, Kirk & Othmer, Vol – 1 & 2
3. Sugar – A User's Guide to Sucrose – N L Pennington and C W Baker
4. Sugar – Science & Technology – G G Birch & K J Parker
5. Sugar – George C Abbott
6. Sugar Chemistry – R S Shallenberger & G G Birch

Instrumental Methods of Analysis

Course: Soft Core, Credit: 03, Lecture: 02hr, Tutorial: 02hr, IA Marks: 30, Exam Marks: 70

Unit 1

Colorimetry & Spectrophotometry:

Theory – definition of transmittancy, absorbency, attenuancy, Beer's law, Lambert's law, molar absorptivity. Instrumentation – radiation sources, filters & monochromators, slits, cells, detectors.

Chromatography: Introduction, classification, applications. **Paper Chromatography:** Principle, types, migration parameters, experimental details of qualitative analysis – filter paper, developing solvent, preparation of samples, spotting, visualization, calculation of R_f value. **Thin Layer Chromatography**: Experimental techniques – coating of materials, preparation of thin layers on plates, activation of adsorbent, purification of silica gel 'G' layers, sample application, developing solvent & methods, detection of components, evaluation of chromatogram, advantages & general applications

Unit 2

Column Chromatography: Principle, Experimental details – preparation of column, adsorbents & solvents, detection & analysis, applications.

Gas – Liquid Chromatography (GLC or GC): Principle, retention volume, instrumentation, carrier gas supply, sample injection system, columns, detectors (FID, TCD & ECD), general applications.

High-Pressure Liquid Chromatography (HPLC): Instrumentation – Mobile phase reservoirs & solvent treatment systems, pumps, sample injection, column packing, detectors; UV, IR, refractive index & fluorescence, general applications.

Reference:

1. Instrumental methods of chemical analysis - Chatwal & Anand
2. Analytical Chemistry - G.D Christian
3. Instrumental Methods of Analysis - H.H.Willard, L.L. Merritt, J.A. Dean & F. A. Settle,
4. Instrumental methods of Chemical Analysis, G.W. Ewing
5. Principles of Instrumental Analysis - Skoog, D.A, S.J. Holler & T.A. Nilman,
6. Principles of Electro Analytical Methods - T. Riley and C. Tomilinsom, Pub. John Wiley.

Chemistry Practical

Course: Hard Core, Credit: 02, Practical: 04hr, IA Marks: 10, Exam Marks: 40

1. Standardisation of laboratory glassware
2. Preparation of acid and alkali solutions of different strengths
3. Determination of specific rotation of sucrose/glucose using polarimeter
4. Separation of sugarcane plant pigments by paper chromatography
5. Enzymic Browning: Polyphenol Oxidase Activity in Sugarcane juice
6. Acid hydrolysis of polysaccharides (Starch, Dextran, Pectin)
7. Determination of reducing sugar using 3, 5-dinitrosalicylic acid
8. Estimation of nitrogen in sugarcane juice by Kjeldahl method
9. Preparation of $Fe(OH)_3$ colloidal solution
10. To study the adsorption of oxalic acid by the activated charcoal
11. Effect of mineral acids on sucrose solution: Determination of specific reaction rate constant for H_2SO_4 and HCl
12. Determination of the capacity of a cation exchange resin.
13. Determination of Ca & Mg in cane juice by EDTA method

Reference:

1. Vogel's Text Book of Practical Organic Chemistry – B S Furniss et al.
2. Semi Micro Qualitative Analysis – Cheronis, Entrikin and Hodnet.
3. Introduction to Sugar Analysis – Mathur.
4. Practical Physical Chemistry – A. Findlay.
5. System of Technical Control in India – N C Verma

Sugar Technology Practical – I

Course: Hard Core, Credit: 02, Practical: 04hr, IA Marks: 10, Exam Marks: 40

1. Determination of total dissolved solids of sugar house products by Hydrometer
2. Determination of refractometric dry substance of sugar house products
3. Determination of apparent Purity of juices and other boiling house products.
4. Determination of melting point of sucrose and boiling point of different concentration sugar solutions
5. Determination of sucrose and calculation of gravity purity by double polarization
6. Preparation of indicator solutions and test papers for pH determination of – Raw Juice (Methyl Orange) & Sulphited Juice (Bromothymol Blue)
7. Determination of pH of various juices and syrup by different methods
8. Determination of Pol % and Fibre % Cane
9. Analysis of bagasse for moisture and pol %
10. Determination of Pol % filter cake
11. Determination of turbidity of clear juice & sugar
12. Determination of preparatory index of prepared cane
13. Determination of mud volume of juice by heating, liming & addition of flocculants

Reference:

1. System of Technical Control in India – N.C Verma (STAI)
2. ICUMSA Methods of Sugar Analysis
3. Handbook of Cane Sugar Technology – R B L Mathur.
4. Introduction to Sugar Analysis – Mathur
5. Sugarcane Factory Analytical Control - Payne
6. Physical and Chemical Methods of Sugar Analysis - Brown and Zerban.
7. Introduction to Sugar Technology – Chen & Chou.

II SEMESTER

Hard Core	Credits (L:T:P)	Required
Sugar Processing - Evaporation	3(2:1:0)	14
Chemical Engineering – Unit Operations	3(2:1:0)	
Technical Control	4(3:1:0)	
Sugar Chemistry Practical	2(2:1:0)	
Sugar Technology Practical II	2(2:1:0)	
Soft Core (Choose 2)		
Statistics & Statistical Process Control	3(2:1:0)	2 X 3 = 6
Mechanical & Electrical Engineering	3(2:1:0)	
Electronics & Instrumentation Engineering	3(2:1:0)	
Biochemical Engineering	3(2:1:0)	
Open Elective (From other departments)		4
		Total 24

Sugar Processing - Evaporation

Course: Hard Core, Credit: 03, Lecture: 02hr, Tutorial: 02hr, IA Marks: 30, Exam Marks: 70

Unit 1

Evaporation: Introduction, Construction & Working of Robert type evaporator, Rellieuxs' principles, working of multiple effect evaporator, factors affecting heat transfer and performance of evaporators. Condensate Extraction, effect of condensate on heat transfer, circulation of condensate - flash pot. Non condensable gases removal, mechanism of suppression of heat transfer. Scaling - distribution of scale, tube cleaning, hydraulic test. Entrainment - catchall, Condensers - Importance of vacuum, description of jet condenser - automation, Steam & Water Ejectors, injection water requirement, injection pumps, spray pond & cooling tower.

Unit 2

Modern Evaporators - Construction & working of Semi Kestner, Falling film evaporator, & Plate Evaporator, working of falling film quintuple sets

Steam Economy: Importance of steam saving, calculation of pressure & temperature drop across multiple effects, steam economy measures adopted at various stations, different vapor bleeding schemes, steam balance calculations of different evaporator configurations, vapour re-compressors (thermo & turbo). Performance Efficiency of evaporators, Dessin's formula, calculation of specific evaporation coefficient.

Syrup Treatment: Effect of syrup quality on crystallisation**,** sulphitation of syrup, construction & working of syrup sulphiter, syrup clarification by phosflotation. SO_2 content of sugar, its disadvantages, production of sulphur free direct consumption sugar, decolorization by activated carbon, ion exchange resins

Reference:

1. Principles of Sugar Technology Vol. 3 - Peter Honig
2. Cane Sugar Handbook - D P Kulkarni
3. Handbook of Cane Sugar Technology – R B L Mathur.
4. Introduction to Cane Sugar Technology – G H Jenkins.
5. Hand Book of Cane Sugar Engineering – E Hugot
6. Introduction to Sugar Technology – Chen & Chou
7. Training Manual for Sugar Factories – Mangal Singh
8. Hand of Book of Cane Sugar – Meade & Chen

Chemical Engineering - Unit Operations

Course: Hard Core, Credit: 03, Lecture: 02hr, Tutorial: 02hr, IA Marks: 30, Exam Marks: 70

Unit 1

Size Reduction: Necessity, mechanism, Rittinger's law, Kick's law, Bond's law, Generalized crushing law, methods of operating crushers, industrial equipments, size reduction in sugar industry.

Screening: Standard screen, screen efficiency, capacity of screen & effectiveness, Ideal & actual screen, screen analysis, equipments for industrial screening, sieve test of sugar.

Leaching and Extraction: Leaching techniques - percolation through solid bed, stationery bed, moving bed and counter current leaching, theory of diffusion, theory of extraction of juice from cane.

Mixing and Agitation: Objectives and requirements, types of mixing and agitation equipments.

Unit 2:

Sedimentation: Motion of a particle through a fluid, terminal velocity, Stokes' Equation, experimental study of sedimentation (jar method), factors which influence rate of settling, Kynch theory, expression for thickener area, flocculation, pH, Zeta potential.

Filtration: Cake filtration, theory of filtration, compressible filter cake, filter aid, washing of filtercake.

Centrifuging: Theory of centrifugation, centrifugal separation, types of centrifugals.

Miscellaneous Separation Process: Separation from Gases **-** Cyclone Separators. Membrane Separation Process**:** Ultra-filtration & Reverse osmosis

Reference:

1. Chemical Engineering, Vol 1,2 & 3 - Coulson & Richardson.
2. Unit Operations of Chemical Engineering – Mcabe, Smith & Harriot
3. Principles of Unit Operations - A S Foust, L A Wenzel, CW Clump
4. Introduction to Chemical Engineering - Walter L Badger & Julius T Banchero
5. Unit operation in Cane Sugar Production – John H. Payne
6. Mass Transfer Operations – R E Treybal
7. Shreve's Chemical Process Industries – G T Austin
8. Unit operations of Chemical Engineering - P Chattopadhya

Technical Control

Course: Hard Core, Credit: 04, Lecture: 03hr, Tutorial: 02hr, IA Marks: 30, Exam Marks: 70

Milling Control

Unit 1

Technical definitions: Fundamental formulae for cane, added water, mixed juice and bagasse; calculation of brix % bagasse, fibre % bagasse, fibre % cane, undiluted juice lost in bagasse % mixed juice, undiluted juice lost in bagasse % fibre, added water % fibre, added water % mixed juice, added water extracted in mixed juice % added water in cane.

Methods of Control: Concept of refractometric brix, true purity**,** differential and inferential methods, primary extraction, secondary extraction using simple and compound imbibition schemes, ideal extraction, mill extraction, plotting of brix curves, brix free cane water, lost juice per cent fibre, reduced mill extraction (Deerr), Whole Reduced extraction (Mittal Formula)

Unit 2

ERQV, Cane preparatory index – Aldrich / Rayner CSIR Australian Method; Methods of comparison of milling efficiency of factories.

Inferential Methods: Calculation of bagasse per cent cane, mixed juice per cent cane, brix per cent cane, undiluted juice per cent cane, undiluted juice in mixed juice per cent cane, added water per cent cane and calculation of weight of cane.

Mathematical formula: Bagasse per unit cane, mixed juice per unit cane and added water per unit cane.

Boiling House Control

Unit 3

Boiling House Control Figures: SJM Formula, Winter's formula, relation between SJM formula and Winter - Carp's formula; Difference between commercial sugar, standard granulated and Equivalent Standard Granulated (ESG) – calculation, clarification factor, actual molasses % theoretical molasses and non-sugar in molasses % non sugar in mixed Juice.

Boiling House Recovery: Calculation of Boiling House Recovery, Basic Boiling House Recovery, Boiling House Performance and Boiling House Recovery (E S G). Comparison of boiling house efficiency of different factories, Virtual Purity of molasses, Reduced Boiling House Recovery (Deerr and Gundu Rao), Reduced overall Extraction.

Unit 4

Various Balances: Preparation of pol balance, brix balance, non sugar balance and crystal balance; comments on various balances and known and unknown sugar losses.

Time Account: Capacity utilisation, crushing rate / 24 hours operation and crushing rate 22 hours operation, Downtime analysis.

Preparation of Performance Reports: DMR, RT -7C & 8C

Reference:

1. System of Technical Control for Cane Sugar Factories in India – N.C.Verma (STAI)
2. Cane Sugar Factory Control - Banerjee
3. Sugarcane Factory Analytical Control - J.H Payne
4. Chemical Control – G M Janekar

Mechanical & Electrical Engineering

Course: Soft Core, Credit: 03, Lecture: 02hr, Tutorial: 02hr, IA Marks: 30, Exam Marks: 70

Unit 1:

Introduction: Prime movers, sources of energy, types of prime movers, force and mass, Pressure, Work, Power, Energy, Heat, Temperature, Units of heat, Specific heat capacity, Internal energy, Enthalpy, Entropy, Efficiency.

Properties of gases: Gas laws, Boyle's law, Charle's law, Combined gas law, Gas constant, Internal energy, Relation between Cp and Cv, Enthalpy.

Steam & Steam Engines: Introduction, Steam formation, Types of Steam, Enthalpy, Specific volume, dryness fraction, use of steam tables. **Heat Engines**: Thermal prime movers, Elementary heat engines, speed regulation – Governors & Fly wheel.

Pumps & Compressors: Introduction, reciprocating pump - types and operation, Centrifugal pumps - types and Priming, Rotary pumps. Air Compressors: Uses of Compressed air, Reciprocating & Rotary compressors.

Transmission of Motion & Power: Introduction, Methods of drive, Power transmission elements, shaft and axle, Belt-drive, Pulleys, Chain drive, Gear drive. Couplings – types.

Unit 2:

Fundamentals of Electricity: Circuit Elements, DC Circuits, Ohm's Law and Kirchhoff's Laws, series & parallel circuits. **Electromagnetism -** Faradays Laws, Lenz's Law, Fleming's Rules, induced EMF, self inductance, mutual inductance.

AC Circuits: 1-phase & 3-Phase Circuits; necessity & advantages of 3-phase systems,.

DC Machines: DC generator - types & constructional features, EMF equation of generator. DC motor – types, working principle, back EMF & its significance, torque equation, DC motor characteristics and applications. Necessity of a starter for DC motor.

Transformers: Principle, construction of transformers (core and shell types). EMF equation, losses, efficiency and voltage regulation

Three Phase Induction Motors: Principle, Types & Constructional features. Slip and its significance. Applications of squirrel - cage and slip - ring motors. Necessity of a starter.

Reference:

1. Elements of Mechanical Engineering, Roy & Choudhary
2. Treatise on Heat Engineering- V P Vasandani & D P Kumar
3. Elements of Mechanical Engineering – K P Roy, S K Choudhury

4. Fundamentals of Electrical Engineering & Electronics – B L Theraja
5. Elements of Electrical Engineering & Electronics – B R Sharma
6. Principles of Electrical Engineering & Electronics – V K Mehta

Electronics & Instrumentation Engineering

Course: Soft Core, Credit: 03, Lecture: 02hr, Tutorial: 02hr, IA Marks: 30, Exam Marks: 70

Unit 1

Basic Electronics: Circuit elements in series & parallel. Semiconductor Devices – Diode as Rectifier, Zener Diode as Voltage Regulator, Transistor as Amplifier. Field Effect Transistor – JFET & MOSFET. Thyrister – Silicone Controlled Rectifier.

Number Systems: Decimal & binary systems, binary addition, subtraction, multiplication, division, use of complement.

Boolean Algebra: Basic laws of Boolean algebra, De-Morgan's theorems, minimization techniques.

Logic Gates: OR, AND, NOT, NOR, NAND, EXOR gates. **Arithmetic Logic Units**: Half adder, full adder, parallel binary adder and subtractor. Introduction to basic configuration of computer.

Unit 2

Instrumentation: Introduction, important terms associated with instruments such as range, span, accuracy, error and sensitivity.

Flow measurement: Types of flow, flow transducers - orifice plate, pitot tube, venturi meter. Description of rotameter, magnetic flow meter, ultrasonic flow meter etc

Temperature measurement- Introduction to filled system thermometers, Expansion thermometers, thermocouples, RTD's, Thermostats and pyrometers.

Pressure measurement - Various units and their conversion, manometers, Bourdon tube, diaphragm, bellows, capsule, strain gauges for pressure measurement.

Level measurement: Direct methods - float methods, magnetic level indicator, magnetic level switches, indirect method - hydrostatic method, radiation method, ultrasonic method and capacitance method.

pH and conductivity measurement: Introduction, different types of sensors, pH meter and conductivity meter.

Control System: Closed Loop System - Basic components. Servo and regulator control. Controllers – P, I, D and On –Off modes. Controller combinations - Final control elements - Valves, actuators and valve positioners.

Reference:

1. Digital Principles and Applications - Malvino Leach
2. Basic Electronics Solid State – B L Theraja

3. Mechanical Measurements – T G Beckwith, Roy D M & J H Lienhard
4. Instrumentation Devices & Systems – Rangan, Sarma & Mani
5. Industrial Instrumentation and Control - S K Singh
6. Principles of Industrial Instrumentation – D Patranabis

Biochemical Engineering

Course: Soft Core, Credit: 03, Lecture: 02hr, Tutorial: 02hr, IA Marks: 30, Exam Marks: 70

Unit 1

Introduction: Bioprocess engineering and technology. An introduction to basic biological sciences. Microbiology: Structure of cells: Prokaryotes and Eukaryotes. Classification of micro-organisms. Taxonomy, control of microorganisms – physical and chemical methods. Biological functions of Lipids, Sugars, Polysaccharides, Amino acids. Vitamins, Biopolymers, Nucleic Acids: RNA, DNA and their derivatives.

Enzymes and Proteins: Detailed structure of proteins and enzymes. Functions. Methods of Production and purification of Enzymes. Nomenclature and Classification of enzymes. Kinetics and mechanism of Enzyme action.

Unit 2

Kinetics of Enzyme Action: Reversible Enzyme. Two-substrate. Multi-complexes enzyme kinetics. Experimental determination of rate parameters: Batch and continuous flow experiments. Batch Kinetics.

Enzyme Inhibition: Effect of Inhibitors, Temperature and pH on the rates enzyme catalyzed reactions. Determination of kinetic parameters for various types of inhibitions. Dixon method. Enzyme immobilization: Uses. Methods of enzyme immobilization.

Unit 3

Fermentation Technology: Ideal reactors: A review of Batch and Continuous flow reactors for bio kinetic measurements. Microbiological reactors: Operation and maintenance of typical aseptic aerobic fermentation processes. Formulation of medium: Sources of nutrients. Introduction to sterilization of bioprocess equipment.

Growth Kinetics of Microorganisms: Transient growth kinetics (Different phases of batch cultivation). Quantification of growth kinetics: Substrate limited growth, Continuous culture: Optimum Dilution rate and washout condition in Ideal Chemostat. Introduction to Fed-batch reactors.

Downstream Processing: Strategies and Steps involved in product purification, methods of cell disruption, Filtration, Centrifugation, Sedimentation, Chromatography, Freeze drying/ lyophilisation and membrane separation processes.

Reference:

1. Bioprocess Engineering, Shuler M. L. and Kargi F, 2002.

2. Biochemical Engineering, James Lee, Prentice Hall, 1992.
3. Principles of Fermentation Technology, Stanbury and Whitekar,
4. Microbiology Concept and Application, Pelczar, Pub; McGraw Hill, 2001 Reprint.
5. Bioprocess Engineering, Pauline M. Doran, 2nd Edition, Prentice Hall, 2009.

Sugar Chemistry Practical

Course: Hard Core, Credit: 02, Practical: 04hr, IA Marks: 10, Exam Marks: 40

1. Determination of SO_2 in sulphited juice/Syrup/jaggery
2. Analysis of effluents for Chemical Oxygen Demand (COD) and Dissolved Oxygen
3. Analysis of raw water for chloride, nitrite and sulphate content
4. Estimation of total hardness of raw water
5. Determination of oxalate/phosphate content in evaporator scales
6. Analysis of lime for calcium oxide
7. Determination of reducing sugars in juices and molasses by Lane & Eynon method
8. Determination of CaO in clear juice.
9. Determination of phosphate content in raw juice
10. Determination of sugar in condensates and quantification by Lovibond comparator
11. Determination of Starch in sugar house products.
12. Determination of Dextran in sugar house products.
13. Determination of conductivity ash in sugar, syrup & molasses

Reference:

1. System of Technical Control in India – N.C Verma (STAI)
2. ICUMSA Methods of Sugar Analysis
3. Introduction to Sugar Analysis – Mathur
4. Sugarcane Factory Analytical Control - Payne
5. Physical and Chemical Methods of Sugar Analysis - Brown and Zerban.

Sugar Technology Practical-II

Course: Hard Core, Credit: 02, Practical: 02hr, IA Marks: 10, Exam Marks: 40

1. Determination of crystal size in slurry and massecuite.
2. Determination of pol and moisture of sugar and calculation of safety factor
3. Determination of sulphited ash in sugar
4. Determination of the colour of the sugar
5. Determination of the colour of the sugar house products
6. Determination of RS/Ash ratio syrups and molasses
7. Determination of insoluble matter in sugar
8. Determination of Iron in cane juice & Sugar
9. Determination of total phenolic content of sugar
10. Determination of crystal % massecuite
11. Analysis of mill juices and plotting of brix curves
12. Determination of Nutsch Purity of molasses
13. Sieving and grading of sugar

Reference:

1. System of Technical Control in India – N.C Verma (STAI)
2. ICUMSA Methods of Sugar Analysis
3. Handbook of Cane Sugar Technology – R B L Mathur.
4. Introduction to Sugar Analysis – Mathur
5. Sugarcane Factory Analytical Control - Payne
6. Physical and Chemical Methods of Sugar Analysis - Brown and Zerban.
7. Introduction to Sugar Technology – Chen & Chou.

III SEMESTER

Hard Core	Credits (L:T:P)	Required
Sugar Processing - Pan Boiling	3(2:1:0)	17
Chemical Engineering - Mass Transfer Operations	3(2:1:0)	
Equipment Capacity Calculations	4(3:1:0)	
Sugar Processing - Finishing Operations	3(2:1:0)	
Equipment Design & Drawing	4(0:1:3)	
Soft Core (Choose 2)		
Allied Sugar Manufacture	3(2:1:0)	2 X 3= 6
Management & Entrepreneurship	3(2:1:0)	
Pollution Prevention & Control	3(2:1:0)	
Engineering Materials	3(2:1:0)	
	Total 23	

Sugar Processing - Pan Boiling

Course: Hard Core, Credit: 03, Lecture: 02hr, Tutorial: 02hr, IA Marks: 30, Exam Marks: 70

Unit 1

Vacuum Pan: Construction & working of batch pan (starting, cutting & dropping of pan), design features – tube length, s/v ratio, types of calendria & down take, heat transfer mechanism, circulation in pan, mechanical circulator, description of vacuum crystallizer, seed crystallizer, pan control instruments.

Continuous Pan: Construction & working of different pans**,** design features & operation horizontal continuous pans, advantages & disadvantages**.** Vertical Continuous Pan – construction & working, advantages & disadvantages.

Unit 2

Pan Boiling: Mechanism of crystallization, Classen's theory of pan boiling, co-efficient of super saturation, crystal per cent in massecuite, different methods of graining, crystal growth, conglomeration, false grain formation, molasses conditioning, massecuite % cane. Boiling schemes (4, 3 & 2), method of boiling low grade and high grade massecuites, conductivity of sugar solutions, use of cuitometer.

Boiling Technique: Cobenze's method of purity control – calculation of grain charge purity, grain cut purity, and massecuite purity, quantities of feed material required in tones and volume, steam requirement for pan boiling, solid balance of boiling and curing, calculation of massecuite % and molasses % for different boiling schemes, exhaustion of molasses – formula, calculation of exhaustion, factors affecting etc.

Sugar Processing - Finishing Operations

Course: Hard Core, Credit: 03, Lecture: 02hr, Tutorial: 02hr, IA Marks: 30, Exam Marks: 70

Unit 1

Crystallisation: Crystallisation while cooling, air cooled & water cooled crystalliser, vertical crystalliser, cooling and reheating of massecuite, transient heater, molasses exhaustion, saturation temperature, mechanical details of crystalliser drive, receiving crystalliser, pumping of massecuite. Oscillating Vertical Crystallizer

Unit 2

Centrifugals: Theory of centrifugals, gravity factor, types of centrifugals, Continuous Centrifugals – construction & working, importance of rpm & screen size, factors affecting curing, of massecuite. Batch Centrifugals**:** Construction & working, Types of drives & controls, washing of sugar, super heated wash water system, molasses/syrup separator, drying of sugar in centrifugals. Description of a curing cycle, sequencing of timers for different operations of a curing cycle, regenerative braking, mesh arrangements, pugmill, magma mixer, molasses pumps, weighing.

Unit 3

Drying & Storage: Characteristics of sugar, construction and working of hopper drier, fluidized bed drier, rotary drier, sieving of sugar -grader, bins, dust collectors, hazards due to sugar dust, grading of sugar, sugar standards, specifications of raw sugar, white sugar and refined sugar. Keeping quality of sugar, safety factor, specification of gunny bag, Sugar bins, storage conditions in godown, construction of godown, storage of final molasses.

Reference:

1. Principles of Sugar Technology Vol. 2 - Peter Honig
2. Cane Sugar Handbook - D P Kulkarni
3. Handbook of Cane Sugar Technology – R B L Mathur.
4. Introduction to Cane Sugar Technology – G H Jenkins.
5. Hand Book of Cane Sugar Engineering – E Hugot
6. Introduction to Sugar Technology – Chen & Chou
7. Training Manual for Sugar Factories – Mangal Singh
8. Efficient Management of Sugar Factories – Mangal Singh

Chemical Engineering - Mass Transfer Operations

Course: Hard Core, Credit: 03, Lecture: 02hr, Tutorial: 02hr, IA Marks: 30, Exam Marks: 70

Unit 1

Mass Transfer: Concept of mass transfer in gases & liquids, classification, molecular diffusion, fick's law, mass transfer by convection & change of phase, molar & mass concentration; mole & mass fraction; molar & mass velocity; molar & mass concentration; molar & mass flux, mass transfer coefficient.

Heat, Momentum and Mass Transfer: By molecular diffusion and eddy diffusion, Reynolds analogy.

Unit 2

Gas Absorption: Effect of partial pressure, equilibrium between gas & liquid, mechanism of gas absorption – two film theory.

Humidification & Water Cooling: Humidification terms, wet bulb temperature, adiabatic saturation temperature, humidity data for air water system, determination of humidity, humidification, and dehumidification. Evaporative cooling, cooling tower, spray pond.

Unit 3

Evaporation: Effect of liquid characteristics, mechanism of heat transfer from condensing steam to boiling liquids, factors affecting heat transfer, boiling point elevation, duhring's rule, calculation of enthalpy balance for single & multiple effect evaporator.

Crystallization: Saturation, solubility and super solubility, nucleation, different systems of nucleation, effect of impurities on crystal formation, crystallisation mechanisms, crystal growth, agglomeration, breakage, crystal size distribution.

Drying & Conveying: General principles, rate of drying, diffusion theory & capillary theory of drying, drying equipments, **Conyers**: types of conveyers, conveyers used in sugar industry.

Reference:

1. Chemical Engineering, Vol 4 - Coulson & Richardson.
2. Unit Operations of Chemical Engineering – Mcabe, Smith & Harriot
3. Principles of Unit Operations - A S Foust, L A Wenzel, CW Clump
4. Introduction to Chemical Engineering - Walter L Badger & Julius T Banchero
5. Unit operation in Cane Sugar Production – John H. Payne
6. Chemical Engineers' Handbook, Perry & Green
7. Momentum, Heat and Mass Transfer – Bennet & Myers
8. Mass Transfer Operations – R E Treybal

Equipment Capacity Calculations

Course: Hard Core, Credit: 04, Lecture: 03hr, Tutorial: 02hr, IA Marks: 30, Exam Marks: 70

Unit 1

General: Selection of site for a sugar factory – economics of factory location, types of layout, land required for factory, requirement of cane area, electricity & water requirement.

Milling: Capacity of cane handling equipments, feeder table, cane carrier (width, length and drive), preparatory devices, crushing capacity of mills, capacity enhancement by adding pressure feeders, Zeroth mill & last mill. Capacity of juice transfer pumps, Power required for preparatory devices, cane carriers and mills**,** mill drive (electric & hydraulic).

Unit 2

Boiler and Electrical: Heating surface of boiler, rating of ID & FD fans, capacity of feed water pumps. Capacity of boiler, turbines & alternators for cogeneration, steam and power balance of factory.

Clarification: Raw juice and maceration pump capacities, capacity of rotary screen, juice & water weighing scale. Juice heater – heating surface, calculation of diameter of steam / vapour pipe, condensate pipe, non-condensable gas outlet pipe. Capacity of sulphitation tanks, sulphur furnace, air compressor, blower**,** lime slacker, milk of lime pump, dorr clarifier, rotary vacuum filter & vacuum pump.

Unit 3

Evaporator: Calculation of heating surface of multiple effect evaporator, calculation of specific evaporation coefficient (Dessin), diameter of vapour inlet & outlet, capacity of condenser, injection and spray pumps, mist cooling system, cooling water requirement, condensate extraction pump, syrup sulphitation tank.

Unit 4

Pan, Crystalliser & Centrifugals: Capacity of supply tanks, capacity of batch & continuous pans by massecuite % cane & solid balance methods, S/V ratio, capacity of crystallisers, centrifugals, molasses pumps, hopper, grader, sugar bins, auto-weighing system, final molasses weighing scale & storage tanks, sugar godown.

Reference:

1. Hand Book of Cane Sugar Engineering – E Hugot
2. Machinery and Equipments for Sugar Factories – L A Tromp
3. Capacity – G M Genekar
4. Sugar Machinery – A J Wallis Tayler

Allied Sugar Manufacture & Co-Products

Course: Soft Core, Credit: 03, Lecture: 02hr, Tutorial: 02hr, IA Marks: 30, Exam Marks: 70

Unit 1

Non Centrifugal Sugars: Manufacture of Jaggery & Khandasari Sugars**,** advantages & disadvantages.

Beet Sugar: Introduction to beet sugar industry, agro-climate condition for cultivation of sugar beet; distribution of sugar in beet, harvesting, transport, dirt removal, beet handling, fluming, beet feeders, trash catchers, tail separators, beet washers, diffusion, clarification and other manufacturing processes.

Raw Sugar: Specification of raw sugar, clarification & pan boiling, storage, handling, transport of raw sugar, keeping quality. Quality criteria for Purchase of raw sugar, raw sugar reprocessing in Indian context.

Refined Sugar: Refining quality of raw sugar – evaluation, calculation of raw value. Affination, clarification, decolorisation, evaporation and pan boiling, centrifugation, sugar drying and conditioning, packing, storing, refined sugar products.

Unit 2

Introduction: Byproducts and co-products of sugar industry, transformation from a sugar factory to sugar complex, electricity as a co-product of sugar industry

Bagasse: Composition, utilisation for paper, fibre board, furfural, briquettes, cattle feed, agriculture mulch and for bio-compost.

Filter Cake: Characteristics of filter cake, use as manure, for production of cane wax & bio compost

Molasses: Composition, alcoholic fermentation - manufacture of rectified spirit, denatured spirit and absolute alcohol; batch and continuous fermentation, working of a distillery, process flow chart of ethanol production, industrial uses of alcohol. Non alcoholic fermentation - manufacture of acetone, lactic acid, citric acid, bio manure from spent wash

Reference:

1. Cane Sugar Hand Book – Chen & Chou
2. Sugar Industry Byproducts - J.K.Pataru.
3. Byproducts of Sugar – Payne.
4. Industrial Utilisation of Sugarcane & Its Co-products - P J Manohar Rao
5. Sugarcane – Agro Industrial Alternatives – G B Singh & S Solomon
6. Manufacture and Refining of Raw Cane Sugar – V E Baikow
7. Technology for Sugar Refinery Workers – Oliver Lyle
8. Hand Book of Sugar Refining – Chung Chi Chou
9. Beet Sugar Technology – R A McGinnis

Management & Entrepreneurship

Course: Soft Core, Credit: 03, Lecture: 02hr, Tutorial: 02hr, IA Marks: 30, Exam Marks: 70

Unit 1

Business Organization: Principles of management, theories & functions, forms of organizations, distinctions, advantages, disadvantages. Establishment of Industry - Criteria for setting up, statutory approvals, sugar policy in India

Management Structure: Chain of command, delegation of authority & responsibility, line - staff organisation, financial organisation, management structure in sugar industry.

Unit 2

Purchase Organisation: Methods of purchasing, methods of storing, system of location of materials, inventory control, procedure of sugar sales

Personnel Department: Staff recruitment procedure, training, discipline, motivation, safety, welfare, personnel administration with reference to sugar industry, labour act.

Unit 3

Production & Productivity: Definition, factors affecting productivity, improvement of productivity, product quality, total quality management (TQM). Quality Circle program.

Finance Management: Elements of cost – calculation of different costs, depreciation – methods of calculating depreciations – interest on capital, idleness, maintenance - equipment replacement policy, loss & profit, budgetary control.

Unit 4

Introduction Entrepreneurship: Definition of Entrepreneur, concept of Entrepreneurship – Evolution of Entrepreneurship, Development of Entrepreneurship.

Small Scale Industry: Definition, characteristics, need and rationale, scope, role & advantages, Steps to Start SSI – Policies, Institutional Support and Government Schemes.

Preparation of Project: Project Identification & Selection, Project Report - contents, formulation, guidelines by Planning Commission, Identification of Business Opportunities, Feasibility Studies; Market, Technical, Financial & Social.

Reference:

1. Industrial Organisation & Management - R K Sharma & S K Gupta
2. Principles of Management - P.C. Tripathi, P.N.Reddy
3. Dynamics of Entrepreneurial Development & Management - Vansant Desai
4. Entrepreneurship Development, Small Business Enterprise, Poornima M Charantimath
5. Management and Entrepreneurship - NVR Naidu and Krishna Rao
6. Management Fundamentals, Concepts, Application, Skill Development, Robert Lusier

Statistics & Statistical Process Control

Course: Soft Core, Credit: 03, Lecture: 02hr, Tutorial: 02hr, IA Marks: 30, Exam Marks: 70

Unit 1

Introduction: Importance of statistics, applications & limitations. Data collection - classification, elements, variables & observations, methods of collection, data sources.

Statistical Methods:

Measures of central tendency (location): definition, arithmetic average, mean, median, mode percentiles & quartiles - exercises.

Measures of Dispersion (variability): definition, range, mean deviation, standard deviation - exercises. Skewness, Moments & Kurtosis – definitions, measures of Skewness, exercises.

Correlation – definition, types, methods of studying - exercises. Regression – definition, methods of studying - exercises. Interpolation & Extrapolation – definition, significance, methods of interpolation - exercises.

Unit 2

Statistical Process Control: Introduction to Quality Control, Definition, types, advantages, sampling techniques, control charts, steps in SPC

Tools & Procedure: Identification & data gathering, Prioritizing (Pareto Charts), analysis of Selected Problem (Fishbone Diagram), Flowcharting (Scatter Plots), Data Gathering & Initial Charting (Check Sheets, Histograms, Probability Plot).

Control Charts: Variable Data Charts: Individual (I chart), Average (X-bar Chart), Range Chart (R-Chart), Moving Range Chart (MR Chart), Combination Charts - IR Charts etc

Reference:

1. Statistical Methods – S P Gupta.
2. Fundamentals of Mathematical statistics – Gupta & Kapur
3. Fundamentals of Statistics – D.N.Elhance
4. Statistics for Management – R I Levin & D S Rubin.

Pollution Prevention & Control

Course: Soft Core, Credit: 03, Lecture: 02hr, Tutorial: 02hr, IA Marks: 30, Exam Marks: 70

Unit 1

Introduction: Importance of environment for mankind. Biosphere and layers of atmosphere. Hydrological cycle and nutrient cycles. Types of pollution. Damages from environmental pollution. Need of environmental legislations and environmental Acts in India. Functions of central and state pollution control boards.

Water Pollution: Sources, classification and characterization of wastewater, Physical and chemical characteristics, BOD, COD and their importance, types of water pollutants and their effects. Sampling and methods of analysis.

Unit 2

Wastewater Treatment: Preliminary, primary, secondary and tertiary treatments of wastewater. Sludge treatment and disposal. Advanced wastewater treatment. Recovery of materials from process effluents. Applications to Industries: Norms and standards of treated water.

Unit 3

Air Pollution: Classification & Sources of air pollutants, Air quality criteria and standards. Effects of air pollution on health, vegetation, and materials. Air Pollution Control methods, and equipment used in industries

Solid Waste Treatment: Origin, Classification and microbiology. Properties and their variation. Engineered systems for solid waste management – generation, onsite handling, storage, collection, transfer and transport, composting, sanitary land filling.

Noise Pollution: Sources & determination of noise levels. Noise control criteria and noise exposure index. Administrative and engineering controls. Acoustic absorptive materials.

Reference:

1. Environmental Pollution Control Engineering - C.S. Rao
2. Pollution Control in Process Industries - S.P. Mahajan,
3. Introduction to Environmental Engineering - Davis
4. Waste Water Engineering Treatment Disposal Reuse - Metcalf & Eddy
5. Environmental Engineering - G.N. Pandey and G.C. Carney
6. Industrial pollution – Technologies for Abatement and Control – R N Mukherjea, et al
7. Hand Book of Waste Management in Sugar Mills and Distilleries – Ashwani Kumar

Engineering Materials

Course: Soft Core, Credit: 03, Lecture: 02hr, Tutorial: 02hr, IA Marks: 30, Exam Marks: 70

Unit 1:

Material Science: Introduction, classification of engineering materials, Level of structure, Structure property relationships in materials. Geometry of crystals, crystal Imperfections, deformation of materials and Fracture

Unit 2:

Atomic Structure, Chemical Bonding and Structure of Solids: Structure of atom, Periodic table, Ionization potential, Electron affinity and electro-negativity, Primary and secondary bonds, Variation of bonding character and properties, Covalent solids, Metals and alloys, Ionic solids, Structure of silica and silicates, Polymers.

Unit 3:

Corrosion and its Prevention: Direct corrosion, Electro-chemical corrosion, Galvanic cells, High temperature corrosion, Passivity, Factor influencing corrosion rate, Control and prevention of corrosion-modification of corrosive environment, Inhibitors, Cathodic protection, Protective coatings, glass lining, lead lining, FRP lining.

Unit 4:

Engineering Materials: Structure & Properties of engineering materials, effect of stress on structure – plastic strain, permanent deformation, slip. Effect of temperature on structure & mechanical properties, effect of environment – corrosion, oxidation & radiation. Ferrous metals, nonferrous metals, alloys, Timber, Abrasive materials, silica, ceramics, glass, graphite, diamond, plastic, polymer and composites as engineering materials.
Heat Treatment: Annealing, Normalizing, Hardening.

Reference:

1. Materials Science and Engineering – A First Course, Raghavan
2. Material Science and Processes, Hajra Choudhury S.K
3. Elements of Material Science, Van Valck H.L

Equipment Design & Drawing

Course: Hard Core, Credit: 04, Practical: 06hr, Tutorial: 02hr, IA Marks: 10, Exam Marks: 40

Introduction:

Basic considerations in design. General design procedure. Equipment classification. Various components of process equipment. Design parameters. Pressure vessel codes. Design Considerations: Material selection. Factors affecting design. Stresses due to static and dynamic loads (Internal & External). Temperature effects. Economic considerations.

Equipments:

Constructional and functional details, material of construction and its mechanical properties, optimum parameters and factors to be considered during design for effective working of sugar process equipments. Design of Juice Heater, Evaporators, Vacuum Pan, Condenser, Crystalliser, Molasses Tank.

Introduction to drawing:

Convention lines, orthographic projection, plan, elevation, end view, isometric projection, reading scale, dimension rules, section and their convention, symbol of different of materials.

Proportionate drawing of process equipment: Equipment and piping symbols, Vessel component; Vessel opening, Manholes, Vessel enclosures, Vessel support, Jackets.

Drawing Practice: Geometrical shapes, Nut-bolt, valves, pumps, Juice Heater, Sulphiter, Evaporator, Pan & Condenser

Reference:

1. Machinery and Equipments for Sugar Industry – L A Tromp
2. Hand Book of Cane Sugar Engineering – E Hugot
3. Engineering Drawing – N.D Bhat
4. Engineering Drawing – K.R Gopal Krishna
5. Process Equipment Design - M. V. Joshi, Macmillan & Co. India, Delhi, 1998.
6. Chemical Engineers Handbook, Perry & Green, McGraw Hill, 1997.
7. Process Equipment Design, Vessel Design – L E Brownell & E H Young

IV SEMESTER

Hard Core	Credits	Required
Factory Practice/Internship (About 4 - 5 months)	6	6
Self Study Electives (Choose 2)		
Alcohol Technology	2	2 X 2 = 4
Water Management & Zero Discharge	2	
Corrosion Prevention & Control	2	
Energy Conservation & Cogeneration	2	
		Total 10

Alcohol Technology

Course: Self Study Elective, Credit: 02, IA Marks: 30, Exam Marks: 70

Unit 1

Introduction: Sugarcane Molasses as raw material, composition, grades, storage of molasses, effect of various components of molasses on distillation. Fundamentals of yeast growth, aerobic & anaerobic, common strains of yeast used for alcoholic fermentation, growth requirements of yeast, Isolation of yeast - preservation & propagation, process flow chart of ethanol production.

Definitions related to Distillery:

Molasses, Total Reducing Sugar, Un fermentable Sugar, Fermentable Sugar, Residual Sugar, wort, Brix, Specific gravity, Industrial Alcohol, Distillation, Ethyl Alcohol, proof Spirit, Strength of Spirit, Reflux, Vaporation, Saccharification, Scaling, Scrubber, Starch-Sucrose, Rectification, Gelatinization, liquefaction, Reboiler.

Unit 2

Fermentation & Distillation: Batch, Fed Batch & Continuous Fermentation. Types of Distillation - **a**tmospheric distillation, MPR distillation, ENA, RS, Production, Process of manufacturing of Anhydrous Alcohol, Dehydration with molecular sieves and membranes.

Distillation System: Description of Column, Materials of Construction & its maintenance, Types of trays, Types of Condensers, Types of Re-boilers. Normal Start up of RS Plant, Equipment wise normal temperature, Emergency shutdown, Problems and trouble shooting, Factors affecting distillation column operation.

Unit 3

Efficiency Data Calculation

Fermentable Sugar, Theoretical Yield, Fermentation Recovery, Sludge loss, Total wash distilled, Distillation Recovery, Distillation Efficiency, Actual Yield, Overall Efficiency and Recovery.

Unit 4

Effluent Treatment & Byproducts of Distillery: Characteristics of effluent, standard norms, waste water treatment - Aerobic & Anaerobic systems. Concept of Zero Discharge - Evaporation & Drying, Spent wash incinerators, Environmental audit of distillery. Production of Carbon dioxide & Methane, fodder yeast, Bio-compost from spent wash.

Reference:

1. Bioprocess Engineering - Shuler M. L & Kargi F
2. Principles of Fermentation Technology - Stanbury and Whitekar,
3. Fundamentals of Multi-component Distillation - C.D. Holland
4. Hand Book of Waste Management in Sugar Mills and Distilleries – Ashwani Kumar

Energy Conservation & Cogeneration

Course: Self Study Elective, Credit: 02, IA Marks: 30, Exam Marks: 70

Unit 1

Introduction: Concept of Cogeneration – Combined heat and energy production, Need for cogeneration in sugar industry, cogeneration potential and achievement in India, National electricity policy, benefits of cogeneration. Bagasse based cogeneration, bagasse as fuel – characteristics, NCV, GCV, Importance of bagasse saving, bagasse drying, alternate fuels – cane trash, filter cake, spent wash etc

Unit 2

Cogeneration Operational Aspects: Types of cogeneration – Topping Cycle & Bottoming Cycle, criteria for selection of cogeneration plant - Boiler & Turbo Generator capacity, Pressure & Temperature of Steam required, Feed Water temperature etc. Cogeneration configuration – Extraction cum back pressure type, Double extraction cum condensing type and Condensing type.

Unit 3

Generation and Export of Power: Generation of electricity, captive power consumption of factory, surplus power export to public grid, infrastructure for power transmission, Efficiency of generation – Disadvantages of low Power Factor, methods of improving, benefits of power factor enhancement. Importance of Plant load factor (PLF) & Station Heat Rate (SHR). Power Tariff determination – Cost based approach & Marginal Cost/Avoided cost based approach.

Unit 4

Energy Conservation & Audit: Electric Conservation measures in various stations of Sugar Plant – Mills/Diffuser, Condensation & Cooling, Crystallisers, Pumping, Crystallisers & Centrifugals. Pinch Technology for energy conservation – energy targets, design guidelines, methods of application. Energy Audit – Definition & Concept, types, methodology for conducting energy audit in sugar industry.

Reference:

1. Energy Conservation and Cogeneration in Cane Sugar Manufacture – D.P Kulkarni & R.K Sidreshmukh
2. Energy Conservation and Alternative Sources of Energy in Sugar Factories and Distilleries – P.J Manohara Rao
3. Proceedings of Workshop on Cogeneration – STAI, Haidargarh, UP
4. Proceedings of ISSCT Combined Energy Workshop, Pune, 1996

Corrosion Prevention & Control

Course: Self Study Elective, Credit: 02, IA Marks: 30, Exam Marks: 70

Unit 1

Corrosion and Control: Mechanism of corrosion, electrochemical aspects of corrosion, economic aspects of corrosion, Forms of corrosion, Factors Influencing Corrosion, Corrosion Control - Proper designing, Use of pure metal, Use of metal alloys, Cathodic protection. Chemical conversion – Coating, Phosphating, Chromising, Use of inhibitors. Corrosion in Sugar Industry

Unit 2

Protective Coatings: Metallic Coatings, Various methods of cleaning metal surfaces before coating, surface cleaning and painting procedure of Clarifier, Sulphiter, Evaporator, Pans, Supply Tanks, Crystallisers, Molasses tanks, condensers etc. Corrosion of pipe line carrying Juice, Vapour, SO_2, Non condensable gases. Corrosion resistant lining – rubber, lead, glass.

Unit 3

Materials of Construction: Materials used in different equipments and machinery in sugar plant, areas prone for high corrosion, factors contributing for corrosion in sugar industry – surface finish, pH, juice constituents (chlorides, sulphides, oxygen), flow rate and water quality. Types of Stainless Steel & Applications of different grades, Criteria for Selection of Stainless Steel - Mechanical & Chemical Properties like strength, fabricability, weldability, corrosion performance, comparison of Stainless steel and other materials.

Unit 4

Corrosion in Boilers: Internal & external corrosion, high temperature corrosion, importance of water treatment to prevent corrosion - role of de-aeration, use of oxygen scavengers, alkalinity of feed water. Corrosion of condensing and Cooling Systems – injection water quality. Corrosion in Turbines – contamination of steam, priming, blow down of steam in pipe lines. Corrosion in Pumps. Corrosion Testing Methods.

Reference:

1. Engineering Materials & their Applications, R A Finn & P K Trojan
2. Corrosion Engineering – Mars G Fontana
3. Scientific & Effective Sugar Plant Maintenance Management – V Singh
4. Materials Science and Engineering – A First Course, Raghavan V,
5. Material Science and Processes - Hajra Choudhury S.K

Water Management

Course: Self Study Elective, Credit: 02, IA Marks: 30, Exam Marks: 70

Unit 1

Raw Water Management: Various sources of raw water, impurities in raw water & removal – raw water conditioning. Water Requirement – for starting the sugar plant (boilers, equipment testing, spray pond/injection channel, service water tank), for normal running (cooling of machinery, make up for boiler & spray pond) & miscellaneous purposes, raw water recycling used for cooling, calculation of water requirement on Cane.

Unit 2

Condensate Management: Quantities of condensate production in various heat exchangers, quantities of condensate required for various purposes, excess condensate cooling & reuse methods of cooling, storage and heat recovery.

Unit 3

Waste Water Management: Classification and sources of waste water, waste water generation during cleaning day and its minimisation/utilisation (caustic soda solution for injection water & effluent pH maintenance), waste water treatment and recycling - primary secondary and tertiary treatment. Flow diagram of water entering and leaving factory, concept of zero discharge in a distillery, Waste water standards for sugar & ethanol plants.

Unit 4

Water Quality: Characteristics of raw and waste water, boiler feed water softening, internal & external conditioning, water sampling & analysis. Specifications for boiler feed water & monitoring its quality, performance of waste water treatment process – problems, causes & remedies.

Reference:

1. Hand Book of Waste Management in Sugar Mills and Distilleries – Ashwani Kumar
2. Environmental Pollution Control Engineering, C.S. Rao, New Age Int.
3. Pollution Control in Process Industries, S.P. Mahajan, Tata Mc Graw Hill, 1999.
4. Introduction to Environmental Engineering, Davis, McGraw Hill, 1998.
5. Waste Water Engineering Treatment Disposal Reuse, Metcalf & Eddy; Tata McGraw Hill.
6. Environmental Engineering, G.N. Pandey and G.C. Carney, Tata McGraw Hill, 2002.
7. Industrial pollution – Technologies for Abatement and Control – R N Mukherjea, et al
8. Waste Water Treatment – M N Rao & A K Data

Factory Practice (Internship/In-plant Training)

Course: Hard Core, Credit: 06, Report: 50 Marks Exam: 50

LABORATORY PRACTICE

Determination of Brix, Pole & Purity of sugar house products, Special Analysis Experiments. Boiler Water and Effluent Analysis. Boiling House Stock taking, calculation of Recovery%, Preparation of DMR

CANE DEPARTMENT

Organisation and working of the department, staffing pattern, duties of field man, cane supervisor etc., cane area of the factory, cane varieties and their acreage, number of registered farmers, sugarcane planting, crop monitoring, post harvest maturity survey, Issue of cutting orders and harvesting procedures, managing harvesting labour and cane transport to factory, managing yard balance, measures to reduce cut to crush delay, varietal improvements, farmers education & training under taken.

MILLING

Cane weighing, cane unloading, operation of feeder table & cane carrier, technical information of preparatory devices and their drives, preparatory index achieved, automation of cane feeding, problems faced & maintenance. Cane conveying to mills, rake carriers, belt conveyors, donnelly chute & pressure feeders, inter carriers.

Working of the Mills – crushing rate, rpm of mills, hydraulic load etc., - roller grooving, pitch, Imbibition %, effect of imbibition on capacity and mill extraction, Mill setting Calculations, Brix Curves and its Significance, pumping of Juice, gutters, pumps & piping details – Mill Drives.

Juice Screening – working of rotary screen (Operation, Cleaning & Maintenance), weighing & metering of juice & water, scale. Problems in Milling and remedies (Operational and Mechanical) Importance of Mill Log Book – staffing pattern (Fitters, Helpers etc) Off - seasonal Maintenance.

BOILER

Technical details of boiler, fuel management, operation of boiler, water level control, maintaining boiler pressure, blowdown, furnace Cleaning – Feed water treatment, condensate management, Make up water, working of DM or RO water plant, Feed pumps – RBC – flue gas heat recovery systems viz., Economiser, Air pre heater – secondary air (SA) fan, Forced draft (FD) fan, Induced Draft (ID) fan, chimney, dust collectors, boiler instrumentation. Bagasse Dryer – construction and working, advantages & disadvantages

Starting of boiler - slow firing, rising the pressure, pressure maintenance – low boiler pressure, back feeding – water high/low other operational problems and solutions. Log book, staffing (boiler attender, fireman, gauge glass attender etc.) Off-seasonal work. Flue gas & boiler water analysis.

POWER HOUSE & ELECTRICAL DEPT.

Turbine, Alternator, AVR-Load distribution – turbine heating, charge over power factor, specific stem consumption-solving problems like priming, low boiler pressure. Power production and distribution, Cogeneration Station, off seasonal job, staffing pattern (Turbine operator, foreman etc.,) Maintenance jobs of Electrical dept – tripping of motors, winding of motors etc.

CLARIFICATION SECTION

Juice Heating : Arrangement and distribution – heating surface, number to tubes, passes and other design parameters – steam/vapor utilization, temperature control taking and cutting heater from service, juice draining, cleaning, checking – double beet valves etc., - condensate extraction and pumping arrangement, non-condensable gases removal. Operational problems viz., Hammering, problems in pumping, leakage.

Preparation of MOL, lime consumption, capacity, storage and pumping, equipment details. grit removal - classifier, importance of quality of lime.

Production of SO_2: Operation of sulphur burner, equipment details, control of sulphur burning rate, temperature controlling, automation of burner. Types of valves, Working of compressor/blower.

SULPHITER: Design of sulphiter, Juice sulphitation technique, proportioning of SO_2 gas and MOL, settling test, technical details - capacity, retention time, operation of equipment, draining of juice during stoppage, juice tanks/monds & pumps, Syrup sulphitation.
Off-seasonal maintenance work in the above stations

CLARIFIER: Technical details of clarifier, preparation of flocculant, dosing, flash tank, operation in underflow and overflow, checking juice and mud level, problems in settling, importance of pH & temperature of clear juice, preservation of juice during shut down,

FILTRATION: Technical details, bagacillo blower, cyclone separator, mud mixer, proportioning of mud and bagacillo, operation of filter, creation of vacuum, details of vacuum pump, baby condenser, moisture trap, vacuum regulation(Heavy/Light), filtrate receiver, washing of cake, judging the operation by observing the colour and thickness of the cake. Troubles in filtration, off-seasonal work in the section

EVAPORATION: Working of multiple effect evaporator/falling film evaporator/semikestner, how to start the evaporator, how to distribute the vacuum, juice level regulation, noxious gas removal, condensate extraction, syrup pump trouble, high level in the bodies, vapor bleeding, vacuum problem, injection pump load checking, condenser spray & jet regulation, pan-evaporator vapor pressure stabilization, syrup load high, other operational problems like vacuum leakage, hammering, low pressure exhaust etc. Working of evaporator before and after cleaning. Heating surface, vapor pipe diameter of different bodies and other

design parameters, instrumentation, pressure/vacuum/temperature of each body. Cleaning of evaporator, water test, vacuum test, Hydraulic test etc., off-season work.

PANFLOOR:

Boiling 'A' massecuite: Quantity of seed, washing and setting of grains, giving drinks, removal of dust, cutting the footing, boiling of massecuite. Managing the syrup, melt, AL load - Checking the brix of the massecuite for dropping, dropping the pan and re starting the pan.

Boiling of B & C massecuite: Graining, graining medium, slurry introduction, hardening, setting the grains, movement water, removal of false grains, boiling the strike massecuite.

Operational problems viz.,: Syrup and molasses load, low vapor pressure, vaccum trouble, want of crystaliser, high temperature boiling, etc., Monitoring the pan floor position, co-ordination between evaporator and panfloor, distribution of pans, capacity utilisation, stream/vapor management during starting and dropping of pans, vacuum crystalliser, seed crystallizer, automation at pans, off-season work.

Working of Spray pond/cooling tower, Injection water pumps, service pump, priming of pump, pump starting, off-season work

CRYSTALLIZER & CENTRIFUGALS

Working of crystallizer, batch/continuous/MVC, distribution of crystallisers, capacity, cooling/reheating, transient heater, air/water cooled crystallizer.

Centrifugals: Type and make, curing of A massecuite, operation of the A centrifugal, operational, mechanical and electrical troubles, curing cold viscous massecuite, operation of continuous centrifugals, controlling of problems. Off-season work.

Sugar Dryer: Working of dryer, drying & cooling, air requirement, conveying, grader, grading of sugar, weighing and bagging, stacking of sugar bags, godown procedures, sugar sales etc. Molasses weighing, Storage, cooling, sales and dispatch.

Effluent Treatment: methods of effluent treatment, norms of various constituents, zero discharge concept, water balance - calculation of water % cane.

GENERAL

Setting up of Sugar Factory, Organizational Structure, History of the factory, welfare activities, corporate social responsibility, functioning of engineering, manufacturing depts., duties and functions of the various section heads. Accounts Dept. - Sugar sales procedure, cost of production of sugar, methods of remuneration, pay role, cane payment etc., Personal Dept., - number of Employees and classification, working of time office. Stores – material arrangement, receipts and Issues, purchase procedures & general administration.

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