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# University of Mysore

(Estd.1916)

## M.Sc. SUGAR TECHNOLOGY

**Flexible Choice Based  
Credit System  
(FCBCS)**



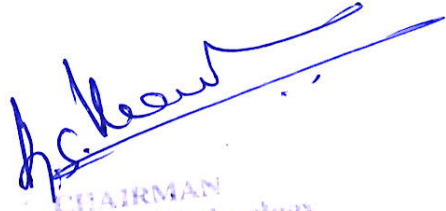
Programme Details



DEPARTMENT OF SUGAR TECHNOLOGY  
Sir M. Visvesvaraya Post Graduate Centre  
Tubinakere, Mandya, Karnataka, India – 571 402

**Regulations and Syllabus**  
**Master of Science in Sugar Technology (M.Sc.)**  
**(Two-year semester scheme)**

**Under**  
**Flexible Choice Based Credit System (FCBCS)**

  
CHAIRMAN  
BOS in Sugar Technology  
University of Mysore  
Sir. M. Visvesvaraya P.G. Centre  
Mandya - 571402

**UNIVERSITY OF MYSORE**  
**GUIDELINES AND REGULATIONS**  
**LEADING TO**  
**MASTER OF SCIENCE IN SUGAR TECHNOLOGY**  
**(TWO-YEAR SEMESTER SCHEME UNDER FCBCS)**

**Programme Details**

Name of the Department	:	Department of Studies in Sugar Technology
Subject	:	Sugar Technology
Faculty	:	Science
Name of the Programme	:	Master of Science in Sugar Technology (M. Sc.)
Duration of the Programme	:	2 years divided into 4 semesters

**Preamble**

Endeavoring to serve the needs of Sugar Industry, the University of Mysore is offering M.Sc. Sugar Technology program since 1993. The course is being conducted under Flexible Choice Based Credit System (FCBCS) scheme since 2017-18. M.Sc. Sugar Technology is a 4-semester course with 4-month internship or in-plant training in a sugar factory. The students go for in-plant training after the completion of first semester for a period of 2 months (Phase I) and again after completion of third semester for a period of 2 more months (Phase II).

**Programme outcome**

- The student has to acquire 4 credits during 3<sup>rd</sup> semester by opting 'open elective' course offered by other Departments or Institutes of the Mysore University
- The student can opt for add on courses for which additional credits will be awarded. On obtaining 20 additional credits a 'Certificate of Proficiency' is awarded.
- The FCBCS involves continuous assessment components C1 (20%), C2(20%), C3(20%), and C4 (40%), assessment based on Written/Oral examination, Assignment, Seminar, factory visits as notified by the individual course teacher.
- Following is the Credit Pattern of the M.Sc. Sugar Technology Course

**Programme Specific outcome**

On completion of the units of syllabus contents, the students will be able to

- Know about cultivation of sugarcane.
- Learn the different agricultural methods of plantation of sugarcane.
- Learn about process of sugar manufacture and jiggery manufacture and ethanol production.
- Know about the different method of purification of the Organic compounds.
- Know about the different types of Carbohydrates and Alcohols.
- Study about the Glucose.
- Know the composition of Cane juice.
- Define Organic acid, Amino acids and Wax
- Understand the concepts of Brix, Pol, Purity, Masseccuites, Molasses, Bagasse.



Scheme of Examination and Details of Course Patterns					
Code	Title of the Paper	HC/SC	Credit pattern (L/T/P)	Credit value	Teaching hours/ week
<b>SEMESTER – I</b>					
ST - 1.1	Sugar Manufacture - I	HC	2/1/0	3	18
ST - 1.2	Sugarcane Agriculture	SC	2/1/0	3	
ST - 1.3	Sugar Engineering I - Electrical & Mechanical Engineering	SC	2/1/0	3	
ST - 1.4	Sugar Chemistry I - Physical & Organic Chemistry	SC	2/1/0	3	
ST - 1.5P	Sugar Chemistry Practical - I	HC	0/0/3	3	
ST - 1.6P	Sugar Technology Practical - I	HC	0/0/3	3	
<b>SEMESTER – II</b>					
ST - 2.1	Sugar Manufacture II	HC	2/1/0	3	18
ST - 2.2	Chemical Engineering I - Heat & Momentum Transfer	SC	2/1/0	3	
ST - 2.3	Sugar Engineering II – Mill & Boiler	SC	2/1/0	3	
ST - 2.4	Sugar Chemistry II - Analytical Chemistry & Biochemistry	SC	2/1/0	3	
ST - 2.5P	Sugar Chemistry Practical - II	HC	0/0/3	3	
ST - 2.6P	Equipment Design and Drawing	SC	0/0/3	3	
<b>SEMESTER – III</b>					
ST - 3.1	Sugar Manufacture III	HC	2/1/0	3	22
ST - 3.2	Technical Control	HC	2/1/0	3	
ST - 3.3	Chemical Engineering II - Unit Operations	HC	2/1/0	3	
ST - 3.4	Sugar Engineering III - Instrumentation Engineering	SC	2/1/0	3	
ST - 3.5	Open Elective (Statistics)	OE	4	4	
ST - 3.6P	Sugar Technology Practical - II	HC	0/0/3	3	
ST - 3.7P	Water Chemistry Practical - Boiler Water & Effluent Analysis	HC	0/0/3	3	
<b>SEMESTER IV</b>					
ST - 4.2	Manufacture IV - Finishing Operations	HC	2/1/0	3	18
ST - 4.2	Equipment Capacity	HC	2/1/0	3	
ST - 4.3	Chemical Engineering III - Mass Transfer	HC	2/1/0	3	
ST - 4.4	Industrial Management & Quality Systems	SC	2/1/0	3	
ST - 4.5	Allied sugar manufacture and by products	SC	2/1/0	3	
ST - 4.6P	Sugar Technology Practical - III	HC	0/0/3	3	
				Total	76
	<b>Add on proficiency course: In-plant Training in a Sugar Factory - 4 Months</b>	SC	0/0/18		18

## FIRST SEMESTER

### HARD CORE

#### COURSE- I: SUGAR MANUFACTURE-I

##### Course Outcomes

- Understand the extraction of the juice and differentiate between primary, secondary and mixed juice.
- Know the purpose of juice heating, construction of juice heaters and types
- Learn the clarification techniques of juice by adopting liming and sulphitation
- Learn the principles of subsidation, application of flocculent and functions of different types of subsidizers like DORR\_444, 555 and SRT
- Learn the working of Vacuum filter and problem solving at filter station
- Learn the evaporation of juice by adopting the different evaporator set.

##### Pedagogy

- Lecturing through PPT and demonstrations are the major methods used.
- Hands-on method is used to demonstrate factory aspects
- Learning through exploring the past research work in their specified fields.
- Factory visits, assignment and seminars.

#### COURSE CONTENT

**UNIT-I: Introduction:** Brief account of Sugar Industry in India and World, sugar manufacturing by sugarcane and sugar beet, composition of Sugarcane and Juice, introduction to different unit operations of sugar manufacture and general working of the factory.

**Extraction:** Crushing of cane in mills, primary, secondary and mixed juice/raw juice, imbibition, importance of juice clarification. Weighing of raw juice and water, construction and working of Maxwell Boulogne Weighing Scale. Measurement of Juice Flow: Different types of flow meters, construction and working of 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-II: 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.

**Technology of Clarification:** Colloids in cane juice, elimination of colloids by juice heating. Reactions of calcium hydroxide, calcium phosphate & other calcium compounds precipitation. Effect of temperature, pH, density & viscosity on cane juice clarification.

**UNIT-III : Subsidiation:** Principle of subsidiation, 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.

**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.

## 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

## COURSE:-II: SUGARCANE AGRICULTURE

### Course Outcomes

On completing the course students will be able to

1. Know the climate factors and cane growth
2. Know the reasons for lodging of sugarcane
3. Know about sugarcane parts and their functions

### Pedagogy

- Lecturing through PPT and demonstrations are the major methods used.
- Hands-on method is used to demonstrate field aspects
- Learning through exploring the past research work in their specified fields.
- Field work, assignment and seminars.

## COURSE CONTENT

**UNIT-I: Introduction:** Origin 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 trans planting & polybag seedling transplanting method.

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

**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, biofertilizers, foliar applications, fertigation, organic & green manuring, time & method of application, visual symptoms of nutrient deficiencies and disorders.

**UNIT-III: 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-IV: Ripening & Harvesting:** Methods of judging ripeness or maturity, factors affecting ripening, accelerating ripening, chemical ripeners. 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, varieties for good ratoons, removal of compaction, gap filling, fertilizer application, water requirement.

**Cane Evaluation and Payment:** Evaluation of cane quality, quality parameters, effect on recoverable sugar, recoverable sugar formulae, cane payment system.

**Sugarcane Breeding:** Introduction, objectives of breeding, breeding methods - germ plasma collection, clonal selection, hybridization, mutation breeding, characteristics of commonly cultivated sugarcane varieties of Karnataka region.

### Sugarcane Agriculture Practical

- 
1. To study external morphology of sugarcane
  2. To study transverse section of root
  3. To study transverse section of stem
  4. To study transverse section of leaf
  5. To study texture of soil
  6. Determination of pH of soil
  7. Determination of carbon/humas content of soil
  8. Study of sugarcane pests
  9. Study of sugarcane diseases



## 10. Study of different varieties of sugarcane

### 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
7. Mechanical Engineering and Electrical Engineering

## COURSE- III: SUGAR ENGINEERING-I (MECHANICAL AND ELECTRICAL ENGINEERING)

### Mechanical Engineering

#### Course Outcomes

On the completion of units of the course contents the students must be able to know about heat energy and generation of steam using boiler, functions of boiler, control devices, safety devices explains various properties of fuel.

#### Pedagogy

- Lecturing through PPT and demonstrations are the major methods used.
- Learning through exploring the past research work in their specified fields.
- Factory visits, assignment and seminars.

### COURSE CONTENT

**UNIT-I: Combustion of fuel:** Chemical principles, air for combustion; calorific values of different fuels – bagasse, firewood, coal, and furnace oil - special characteristics of bagasse combustion, fuel economy, products of combustion, heat losses in flue gas.

**Boiler:** Classification, boiler mountings and accessories, description and working of high-pressure boilers, performance of boilers, equivalent evaporation, thermal efficiency of boilers, heat transfer in boilers, safety precautions, Indian boiler regulations in brief.

**Boiler Furnace:** Requirements in furnace design, control of furnace operations, types of furnaces - Spreader Stoker, Pulsating Grate, Dumping Grate, Travelling Grate, furnace cleaning. Natural and artificial draught - Induced draught, forced draught, balanced draught, chimney, flue ducts. Description and working of super heaters, economisers, air preheater and their contribution to heat recovery. Drying of bagasse using flue gas flue gas analysis by (CO<sub>2</sub>, O<sub>2</sub> and CO), particulate emission, dust collector – types (ESP).

**UNIT-II: Boiler Instrumentation & Control:** Combustion control, three element water level regulators, instruments used in furnaces, operation and control.

**Boiler Feed Water:** Condensate contamination, de-aerator, feed water specifications, internal & external treatment of water, make up water – DM & RO treatment, condensate balance of a sugar factory.

**Properties of steam:** Formation of steam, total heat of water; dryness fraction, liquid heat; latent heat and sensible heat; wet, dry saturated & superheated steam, use of steam tables

**Entropy:** Introduction, entropy of a substance, gases & steam. Isotropic process of steam, throttling process, temperature – entropy diagram, isothermal and adiabatic line, enthalpy – entropy diagram.

**Steam turbines:** Classification, description & working of backpressure, extraction, and condensing type turbines.

## Electrical Engineering

### COURSE CONTENT

**UNIT-I: Fundamentals of Electricity:** Current in a conductor, potential difference, resistance, Ohm's law, Resistance in series & parallel, specific resistance, conductivity. Conductance, Capacitance - Capacitors in parallel and series, types of capacitors. Kirchoff's laws. Power and Energy - Illustrative examples.

**Electromagnetism:** Review of field around a conductor and coil, magnetic flux. Electromagnetic induction: Definition, Faradays Laws, Fleming's right hand rule, Lenz's Law, Statically and dynamically induced EMF. Self inductance, mutual inductance. Force on current carrying conductor placed in a magnetic field, Fleming's left hand rule.

**DC Machines:** Construction and working of DC generator and Motor, types of armature windings, EMF equation of a generator, relation between induced EMF and terminal voltage. Operation of DC motor, back EMF and its significance, torque equation. Types of DC motors, characteristics and applications. Necessity of a starter for DC motor. Illustrative examples on back EMF and torque.

**UNIT-II: AC Circuits & AC Generation:** Basic concepts in R-L, R-C & R-L-C circuits, necessity and advantages of three phase systems, generation of three phase power. Three Phase Synchronous Generators - Principle of operation, Types and constructional features, advantages of rotating field type alternator, synchronous speed, frequency of generated voltage, EMF equation.

**Transformers:** Necessity of transformer, Principle of operation and construction of single-phase transformers (core and shell types) - EMF equation, voltage regulation and its significance.

**Three Phase Induction Motors:** Principle, types and constructional features, concept and production of rotating magnetic field, synchronous speed, rotor speed, slip, frequency of the rotor induced EMF, Slip and its significance. Applications of squirrel - cage and slip - ring motors. Necessity of a starter, starting of motor using star-delta-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

### COURSE-V: SUGAR CHEMISTRY I (PHYSICAL CHEMISTRY AND ORGANIC CHEMISTRY)

## Course Outcomes

The student will gain basic understanding of phytochemicals of sugarcane and their influence on sugar manufacture. The student will be able to solve any process related problems effectively which arise during sugar manufacture in a sugar factory.

## Pedagogy

Class room teaching through multimedia presentation. Recapitulation of previous day covered syllabus from the students for the initial 10 min everyday in class. Students were asked to write assignment concisely on a given topic. Student evaluation was carried out through tests (Multiple choice questions) and seminar.

## COURSE CONTENT

**UNIT-I: Chemical kinetics:** Order of a reaction, Mechanism of chemical reactions - Inversion of sucrose, role of inversion of sucrose in sugar processing, mutarotation of sugars.  
**Colloids:** Introduction, types & properties of colloids, classification of colloids - Lyophobic and lyophilic sol, size, range, properties of colloidal systems, Electrical properties, charge on colloidal particles - isoelectric point, zeta potential, coagulation of colloidal solutions.  
**Adsorption:** Theory of adsorption, difference between adsorption and absorption, adsorbent, adsorbate, Chemisorption and Physisorption, positive and negative adsorption, factors influencing adsorption. Adsorption of coloring matter, use of activated carbon in sugar refining. Ion Exchange Resins: Types, theory of ion exchange process, applications.  
**Kinetic Theory of Gases:** Molecular velocities - Diffusion rate - Diffusion through cane - Milling process. Laws of evaporation. Osmosis; Reverse Osmosis.  
**Colligative Properties:** Vapour pressure, elevation of boiling point - Raoult's law.

**UNIT-II: Solids in cane juice:** Specific gravity of sugar solutions - effect of temperature, Introduction to various methods of solids determination, Densimetric methods (Solution factor & Specific gravity). Methods of determination of specific gravity by i) Specific gravity bottle or Pycnometer, ii) Displacement methods - Hydrometers, determination of brix by dilution.  
**Refractometric method of solids determination:** Principle of refraction - law of refraction, total reflection, Types of refractometers - Abbe's refractometer, hand refractometer, digital refractometer, solids by drying, relation between brix & dry substance, % RDS.  
**Optical Methods of Sugar Analysis:** Polarized light, specific rotation of sugars, factors affecting specific rotation, polarization by nicol prism, Polarimeter, Saccharimeter, normal weight of sugar, international sugar scale, Specific rotation of sugars - effect of temperature, solvent and impurities. Simple polarization - clarifying agents and errors- acetates of lead (neutral & basic lead sub acetate), action of lead sub acetate on specific rotation of sucrose & amino compounds, comparison of different clarifying agents. **Double Polarization:** Principle of double or invert polarization, Clerget constant, Polarisation by destroying optical activity of reducing sugars.

**UNIT-III: Carbohydrates:** Classification, structure, general properties and functions.  
**Monosaccharides;** Introduction, Physical properties of dextrose, levulose & invert sugar (solubility, density, refractive index, optical rotation), chemical reactions of dextrose & levulose with organic reagents (formation of glycosides, acetates, benzoates, carbonates) & inorganic reagents (phosphates, borates etc). Decomposition reactions (acid & alkaline solutions) & oxidation reactions. Methods of analysis of reducing sugars.  
**Disaccharides:** Sucrose - structure, physical (aqueous, optical & electrical properties), chemical properties (hydrolysis, oxidation, alkaline & thermal decomposition, decomposition

by strong mineral acids), nutritional aspects. Uses of sucrose (food applications, feedstock for chemical synthesis, fermentation feed stock, pharmaceutical applications). Derivatives of Sucrose; ethers, esters, polymeric intermediates. Uses of sucrose (food applications, feedstock for chemical synthesis, fermentation feed stock, pharmaceutical applications). Derivatives of Sucrose; ethers, esters, polymeric intermediates.

**Polysaccharides:** Classification, structural studies, polysaccharides of sugarcane – cellulose, starch - effect of starch on sugar processing and its removal. Dextran - Structure and formation of dextran, effect of dextran on sugar processing & its removal.

### 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

## COURSE-VI : SUGAR CHEMISTRY PRACTICAL - I

### Course Outcomes

The student will gain hands on experience in analyzing sugar house products for various phytochemicals.

### Pedagogy

Experiments were appropriately designed and the student was instructed to carry out the experiment with known standard as well as with unknown sample. The student was further asked to note his observation and record his inference with a final report. Student was evaluated for his hands on skills through practical tests from the course covered previously.

### COURSE CONTENT

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  $\text{Fe}(\text{OH})_3$  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  $\text{H}_2\text{SO}_4$  and  $\text{HCl}$
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

## COURSE –VII: SUGAR TECHNOLOGY PRACTICAL – I

### Course Outcomes

After completion of this practical class, the students will be able to :

- Understand how to carry out the special experiments with special instruments / equipments
- To develop best skills in handling instruments / equipments and taking reading in the practical classes.

### Pedagogy

- Experimental demonstrations are the major methods used.
- Hands-on method is used to demonstrate field aspects
- Learning through exploring the past research work in their specified fields.
- Factory samples are also used.

### COURSE CONTENT

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.

**HARD CORE  
SECOND SEMESTER**

**COURSE-I : SUGAR MANUFACTURE -II(EVAPORATION)**

**Course Outcomes**

After the completion of the units of the course students are able to learn


- The construction and working of modern evaporators like semi kestner, FFE rising film type evaporators and steam economy.
- The treatment of Syrup and fundamentals of crystallization
- The pan boiling techniques, Mechanism of crystallization, methods of graining and construction and working batch pan, vacuum crystallizer and pan control instruments.

**Pedagogy**

- Lecturing through PPT and demonstrations are the major methods used.
- Hands-on method is used to demonstrate factory aspects
- Learning through exploring the past research work in their specified fields.
- Factory visits, assignment and seminars.

**COURSE CONTENT**

**Unit I**



**Evaporation:** Introduction, Construction & Working of Robert type evaporator, Rellieux's 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 II**

**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.

### Unit III

**Syrup Treatment:** Effect of syrup quality on crystallisation, sulphitation of syrup, construction & working of syrup sulphiter, syrup clarification by phosflotation. SO<sub>2</sub> content of sugar, its disadvantages, production of sulphur free sugar, Treatment of Melt: Filtration, 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

### COURSE-II: Chemical Engineering - I (Heat and Momentum Transfer)

#### Course Outcomes

After the completion of the units of the course students are able to learn

- Importance of fluid mechanics
- Basic principles and prosperities of fluids
- Renolds numbers and its use
- Heat transfer calculations

#### Pedagogy

- Lecturing through PPT and demonstrations are the major methods used.
- Hands-on method is used to demonstrate factory aspects
- Learning through exploring the past research work in their specified fields.
- Factory visits, assignment and seminars.

### COURSE CONTENT

#### Unit I

Elementary chemical engineering concepts, concept of unit operations. **Stoichiometry:** Introduction, applications in industrial problems, chemistry of combustion reactions, combustion of sulphur & bagasse.

**Heat transfer:** Modes of heat transfer (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, Nusselts 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 II

**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, venturi meter, rotameter and pitot tube.

## COURSE-III: SUGAR CHEMISTRY PRACTICAL-II

### Course Outcomes

The student will develop skills in biochemical/microbiological techniques having wide applications in sugar factory/distillery.

### Pedagogy

Experiments were appropriately designed and the student was instructed to carry out the experiment with known standard as well as with unknown sample. The student was further asked to note his observation and record his inference with a final report. Student was evaluated for his hands on skills through practical tests from the course covered previously

### COURSE CONTENT

1. Preparation of phosphate and citrate buffers
2. Determination of  $\lambda_{max}$
3. Qualitative analysis of carbohydrates.
4. Preparation of solid derivatives of monosaccharide – Osazones.
5. Determination of total Carbohydrate content in sugar by anthrone method.
6. Determination of total activity of  $\alpha/\beta$  amylase a) Standard curve for maltose b) Determination of rate of amylase activity
7. Determination of optimum temperature for  $\alpha/\beta$  amylase



8. Determination of optimum pH for  $\alpha/\beta$  amylase
9. Inhibition of enzymes – pH, temperature and chemicals
10. Estimation of protein by FC method
11. Preparation of microbial culture media and sterilization.
12. Gram staining
13. Microbial count in sugar samples by pour plate method
14. Isolation of microorganisms from sugar samples
15. Demonstration of Microbial motility
16. Determination of PPO Activity in Sugarcane Juice

#### Reference Books:

1. Microbes in Action, A Laboratory Manual of Microbiology Seley et al., (19) W.H.Freeman.
2. Basic and Practical Microbiology, Ronald L. Atlas (1986) McMillan Publication Co.
3. Principles and Techniques of Biochemistry and Molecular Biology; 7th Edn. Keith Wilson and John Walker (2012).
4. Modern Experimental Biochemistry – Rodney Boyer, 2000, Pierson Ed
5. Laboratory Manual in Microbiology – P Gunesekaran, New Age Int Pub, 1995

### COURSE- IV: EQUIPMENT DESIGN & DRAWING

#### Course Outcomes

After the completion of the units of the course students are able to learn

- To illustrate with sketch how parts can be joined by rivets in different forms
- To know how to draw, bolt, nut and its assembly
- To know the some important sugar manufacture equipments like juice heater evaporator pans, crystallizer etc
- To have better understanding about their function

#### Pedagogy

- Drawing with drawing boards and mini drafts in the classroom.
- Assignments and design calculations
- Confirmations through factory setup.

### COURSE CONTENT

**UNIT-I: 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.

**UNIT-II: 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.

**UNIT-III: 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.

**UNIT-IV: 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

### SOFT CORE

### COURSE- V: SUGAR ENGINEERING - II (MILL AND BOILER)

#### Course Outcomes

After the completion of the units of the course students are able to learn

- Cane transportation, weighing, payment methods to farmers unloading of cane, feeder table, cane carrier, preparatory devices like I, II knives Fibrizer/shredder mill drives, hydraulic drives, juice pumps and boiler water treatment and steam generation.

#### Pedagogy

- Lecturing through PPT and demonstrations are the major methods used.
- Learning through exploring the past research work in their specified fields.
- Factory visits, assignment and seminars.

### COURSE CONTENT

#### Unit 1

**Supply and Handling of Sugarcane:** Cane harvesting methods – manual & mechanical, green cane & burnt cane, cane transporting, cane weighing, cane yard, deterioration of cane. Cane unloading – grab, sling & bar, tippers, end tipping trucks. Feeder table & auxiliary carrier. Cane conveying – belt conveyor, chain & slat conveyor – auto cane feeding, tramp iron separators. Cane preparatory devices: Levellerknives, shredder, fibrizer, factors affecting preparation, effect of cane preparation on mill extraction.

#### Unit II

**Milling:** Structure of cane, Mills – description & type, hydraulic system. Roller grooving – messchaert – lotus roller. Mill drives (Electric & Hydraulic drives), coupling (direct & rope) and tail bars. Pressure feeders, roller surface preparation – chevrons, donnellychute. Imbibition, mill sanitation. Low Pressure extraction - two roller mill. **Mill Setting:** Calculations by different methods Bagasse drying - types of drier

### Unit III


**Cane Diffusion:** Introduction, mechanism, factors affecting diffusion, types of diffusers - dewatering of bagasse, pH control, corrosion control in diffusers. Comparison with milling - juice quality, colour, recovery.

### Unit IV

**Electricity Generation:** Steam Turbines - description & working of extraction & condensing type turbines, specific steam consumption of turbine. Alternators: type, efficiency, 3 phase AC generation, power transmission system,

**Cogeneration** – Cogeneration in sugar industry, cogeneration potential and achievement in India, National electricity policy, bagasse based cogeneration. Types of cogeneration – Topping Cycle & Bottoming Cycle, Cogeneration configuration – Extraction cum back pressure type, Double extraction cum condensing type and Condensing type. Energy Conservation measures in various stations of Sugar Plant Energy Audit – Definition & Concept, types.

### References

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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

## **COURSE-VI: SUGAR CHEMISTRY - II (ANALYTICAL CHEMISTRY & BIOCHEMISTRY)**

### **Course Outcomes**

The course gives the student an idea about various phytochemicals/biomolecules of sugarcane plant. The student will be able to appreciate the importance of enzymes during sugar/alcohol manufacture. Also, the student gets acquaintance to various analytical techniques routinely carried out in a sugar factory.

### **Pedagogy**

Class room teaching through multimedia presentation. Recapitulation of previous day covered syllabus from the students for the initial 10 min everyday in class. Students were asked to write assignment concisely on a given topic. Student evaluation was carried out through tests (Multiple choice questions) and seminar.

## COURSE CONTENT

### Unit I

**Laboratory Management and Safety:** Caring of samples & containers, preservation of samples, caring of optical instruments, use and caring of pH meters and electrodes, safety and first aid in laboratory.

**Strength of solutions:** Mole, Normality, Molarity, Molality, Formality, ppm, ppb, ppt, Mole fraction, Equivalent weight and Numericals based on it.

**Colorimetry & Spectrophotometry:** Theory – definition of transmittance, absorbance, attenuancy, Beer's law, Lambert's law, molar absorptivity. Instrumentation – radiation sources, filters & monochromators, slits, cells, detectors. Colour - factors affecting the colour measurement, colour of sugar solution by ICUMSA methods (GS-9, GS-10).

**Estimation of Reducing Sugars:** Reduction of copper by hexoses, estimation of reducing sugars - Lane & Eynon method, Spectrophotometric methods.

**Methods of Sampling:** Introduction & general principles, sampling of sugarcane (field & cane yard), prepared cane, bagasse (first mill to last mill), raw juice (primary, secondary, LEJ, FEJ, mixed juice), treated juice (defecated, sulphited), clear juice, filter cake, massecuite, magma, molasses (intermediate & final), sugar (intermediate & bagging).

**Electrochemistry:** Basic concepts of measurement of electrical conductivity. Strong and weak electrolytes, Specific conductivity, Molar conductivity, Equivalent conductivity. Conductance measurement, solubility product, relation of conductivity of sugar solutions to their ash content, cuitometer, Determination of conductivity ash by ICUMSA method, EMF measurements; measurement of pH using hydrogen electrode.

### Unit II

Characteristics of water. Acids and Bases: Modern concepts of acids and bases-Arrhenius, Lowry- Bronsted and Lewis concepts. Hydrogen ion concentration - pH, pH of some biological fluids and its importance. Buffers: Definition, types, buffer action and buffer capacity.

**Amino Acids & Proteins:** Classification, general properties and chemical reactions of amino acids. Acids present in sugarcane juice, Role of amino acids in sugar manufacture - Maillard reaction. Proteins: Classification, Structural properties, Denaturation of proteins, proteins in cane juice, its removal and colour reactions of proteins

**Enzymes:** General characteristics, nomenclature and classification of enzymes, holoenzyme, apoenzyme, prosthetic group. Measurement and expression of enzyme activity. Definitions of IU, Katal, enzyme turnover and specific activity. Enzyme kinetics- Michaelis-Menten equation, Significance of  $K_m$  and  $V_{max}$  and their determination using Line Weaver- Burk plots. Effect of pH and temperature. Enzyme Inhibition. Biochemical synthesis of Sucrose and Dextran in sugarcane.

### Unit III

**Lipids:** Classification, structure, properties and functions.

**Phytochemicals:** Polyphenols, Terpenes, lignin, waxes, alkaloids.

**Non Sugars:** Introduction to nonsugars in sugarcane, behavior of non sugars (such as non-nitrogenous organic acids, nitrogen containing nonsugars, complex organic nonsugars of high molecular weight, lipids and inorganic nonsugars) during sugar manufacture process.

**Colored Non Sugars:** Colored non sugars present in sugarcane (chlorophyll, xanthophylls, carotene, anthocyanin), nonsugars in sugarcane which may develop colour (polyphenols & amino compounds), colored nonsugars from sugar decomposition products (caramel, hexose degradation products & Maillard reaction products).

**Reference:**

8. Organic Chemistry - R.T. Morrison & R.N. Boyd.
9. An Introduction to Carbohydrate Chemistry – J.Haneymon and Guthrie
10. Text Book of Physical Chemistry- S.Glasstone.
11. Principles of Physical Chemistry - Puri, Sharma & Phathania
12. Principles of Sugar Technology, Vol 1- P. Honig
13. Physical and Chemical Methods of Sugar Analysis – Brown & Zerban
14. Biochemistry – Voet & Voet
15. Principles of Biochemistry - Lehninger
16. Plant Biochemistry - Dey & Harborne
17. Modern Experimental Biochemistry - Rodney Boyer
18. Instant Notes in Biochemistry - David Hames & Nigel Hooper

### THIRD SEMESTER

#### HARD CORE

#### COURSE -I: SUGAR MANUFACTURE III (PAN BOILING)

##### Course Outcomes

On the completion of units of the course contents the students must be able to

- know about details of batch pan, continuous pan, boiling techniques, crystallizers, types, centrifugals, drying and also raw sugar and refined sugar manufacturing techniques.

##### Pedagogy

- Lecturing through PPT and demonstrations are the major methods used.
- Learning through exploring the past research work in their specified fields.
- Factory visits, assignment and seminars.

#### COURSE CONTENT

##### Unit I

**Fundamentals of Crystallisation:** Rate of crystal growth (effect of concentration, temperature & stirring) mechanism of growth (diffusion, viscosity, colloids, stirring & crystallographic considerations) impurities, dissolution & re-growth. Decomposition of sucrose during crystallisation, nonsugars affecting sugar crystallisation, Conductivity of sugar solutions - Cuitometer.

##### Unit II

**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.

#### Unit III

**Vacuum Pan:** Construction & working of batch pan (starting, cutting & dropping of pan), design features – tube length, s/v ratio, types of calandria & 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 IV

**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.

#### 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

### COURSE-II : TECHNICAL CONTROL

#### Course Outcomes

On the completion of units of the course contents the students must be able to know

- Technical definitions of sugar factory, types of juice and its composition, brix, pol purity of all the intermediate products, mid efficiency, RME purity drop, primary extraction, secondary extraction, boiling house, derivation of SJM formula, brix curves etc.,
- One can master over controle of the process by these datas.
- Any variation in data can be easily find the problems.

#### Pedagogy

- Lecturing through PPT and demonstrations are the major methods used.
- Learning through exploring the past research work in their specified fields.
- Factory visits, assignment and seminars.

## COURSE CONTENT

### 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.

Diversion of B-Heavy Molasses for production of alcohol, solid balance, etc

**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

## COURSE-III: CHEMICAL ENGINEERING (UNIT OPERATIONS)

### Course Outcomes

On the completion of units of the course contents the students must be able to know

- Size reduction, screening, mixing, gas absorption, techniques and problems

### **Pedagogy**

- Lecturing through PPT and demonstrations are the major methods used.
- Learning through exploring the past research work in their specified fields.
- Factory visits, assignment and seminars.

## **COURSE CONTENT**

### **Unit I**

**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, stationary 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.

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

### **Unit II**

**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 I - Coulson & Richardson.
2. Unit Operations of Chemical Engineering – McCabe, 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 Banchemo
5. Unit operation in Cane Sugar Production – John H. Payne
6. Chemical Engineers' Handbook, Perry & Green, McGraw Hill, 1997
7. Unit operations of Chemical Engineering - P Chattopadhyaya



## COURSE- IV: SUGAR TECHNOLOGY PRACTICAL – III

### Course Outcomes

On the completion of units of the course contents the students must be able to know

- To train the students on basic principles involved in determination of juice, brix, Pol and purity
- To determine each mill juice quality, ICUMSA methods, SO<sub>2</sub> content, Ash contents, floc test

### Pedagogy

- Experimental demonstrations are the major methods used.
- Hands-on method is used to demonstrate field aspects
- Learning through exploring the past research work in their specified fields.
- Factory samples are also used.

### COURSE CONTENT

1. Determination of crystal size in Slurry and Masecuite.
2. Determination of Coefficient of Variation (Cv) in Sugar and Slurry
3. Determination of Pol% and Moisture% of sugar and calculation of safety factor
4. Determination of sulphited ash and conductivity ash in sugar
5. Determination of the colour of the sugar by ICUMSA GS-2/3-10 and GS-2/3-9 methods
6. Determination of SO<sub>2</sub> content in sugar
7. Determination of Starch in sugar
8. Determination of Dextran in Sugar by Haze Method
9. Floc Test of Sugar
10. Determination of Reducing Sugar in Sugar by Luff's Method
11. Determination of Phenolic content of sugar
12. Determination of Iron in Sugar
13. Determination of Turbidity of Sugar
14. Determination of grade of the sugar by standard sieves and colour by standard sugar bottles
15. Analysis of Jaggery / Gur ( Purity, Reducing Sugar, Net Rendement)
16. Determination of Total Solids and Suspended Solids in Molasses
17. Determination of Fermentable and Un-fermentable sugars in Final molasses and B - Heavy Molasses
18. Determination of organic volatile acids in Molasses

### 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.



## **COURSE- V: WATER CHEMISTRY PRACTICAL (BOILER WATER AND EFFLUENT ANALYSIS)**

### **Course Outcomes**

After completion of this practical class, the students will be able to :

- Water quality, boiler water analysis, water standards, statutory norms ISS standards

### **Pedagogy**

- Experimental demonstrations are the major methods used.
- Hands-on method is used to demonstrate field aspects
- Learning through exploring the past research work in their specified fields.
- Factory samples are also used.

### **COURSE CONTENT**

1. Estimation of the pH –colorimetric method or use of the indicators and electronic method.
2. Determination of Alkalinity of water
3. Determination of the type extent of acidity
4. Determination of carbonate, bicarbonate and hydroxide alkalinity
5. Determination of the type extent of acidity
6. Estimation of the hardness of water
7. Estimation of chloride concentration
8. Determination of dissolved oxygen and percentage saturation
9. Determination of biochemical oxygen demand (BOD) waste water
10. Determination of chemical oxygen demand (COD).
11. Determination of the chlorine demand and chlorine residuals
12. Determination the ammonical nitrogen of the sample
13. Determination of Kjeldahl nitrogen (organic) of the sample.
14. Determination of nitrite nitrogen
15. Estimation of total Phosphates
16. Determination of Sulphates
17. Determination of Chlorine demand and chlorine residuals.
18. Determination of total dissolved solids (TDS)
19. Find out of oil and sugar traces
20. Determination of Turbidity.
21. Estimation of optimum alum dose for coagulation
22. Salient feature of the Water Act (procedure and control)
23. Analysis of Raw Water for suspended solids, organic matter and dissolved solids
24. Analysis of sugar factory / Distillery effluent for total solids, suspended solids (non filterable residue), Dissolved solids (filterable solids), Oxygen absorbed value (O A Value)
25. Determination of Nitrite by colourimetric method / Diazotization method
26. Determination of Sulphite

## SOFT CORE

### COURSE-VI: SUGAR ENGINEERING-III ( INSTRUMENTATION ENGINEERING AND PROCESS CONTROL)

#### Course Outcomes

After completion of this practical class, the students will be able to :

- Basics concepts of measuring of temperature, flow, liquid level, humidity, process control, automatic control, computerised process control, process control in sugar industry.

#### Pedagogy

- Lecturing through PPT and demonstrations are the major methods used.
- Hands-on method is used to demonstrate factory aspects
- Learning through exploring the past research work in their specified fields.
- Factory visits, assignment and seminars.

#### COURSE CONTENT

##### Unit I

**Basic Concept of Measurement:** Purpose of Instrumentation – Measurement and its aim- Functional elements of Instruments – Static and Dynamic characteristics of Instruments - Signaling and Recording Instruments.

**Measurement of Temperature:** Methods of temperature measurement - Liquid filled thermometer- Gas filled thermometer - Thermocouples –Temperature Transmitter.

**Measurement of Pressure:** Types of pressure, methods of pressure measurement - bourdon gauge, bellow and diaphragm pressure sensors. Vacuum measurement; Pirani gauge - Ionization gauge.

**Measurement of Flow, Liquid Level and Humidity:** Methods of flow measurement- Orifice meter–venturimeter- Rotameter- Pitot tube- Weirs and Flumes - Electromagnetic Flow meter- Turbine flow meter. **Liquid level measurement:** Sight glass, Float - tape level indicator- Air purge system - capacitive and conductivity type level sensor. Humidity measurement: Hair Hygrometer – sling Psychrometer.

##### Unit II

**Process Control:** Automatic control system, terminology used in control system; controlled variable, manipulated variable, set point, etc. General process control system; open loop system, closed loop system, feedback control system, feed forward control system and Ratio control system.

**Automatic Controllers:** controllers- classification; PID controller, actuating medium such as Pneumatic, Hydraulic and Electronic – Actuators - Pneumatic Relays - Final control element: control valves, variable speed drives and variable electric power actuator.

**Computerised Process Control:** Introduction, process control computers – centralized control system (CCS), Distributed Controlled System (DCS) in unit operation, unit process and plant control. **Simulation:** Basic concepts - Analog simulation, Digital simulation and Hybrid simulation

##### Unit III

**Process Control in Sugar Industry:** Description and schematic diagrams for the control of sugar processing operations viz., Cane Carrier Control, Mill Control, Boiler Control (Pressure & Flow measurement of steam, water level), De-super heater control, liming and sulphitation pH Control, Steam Turbine Control, Water Treatment Control, Heat exchanger, condenser & evaporator control, crystallizer control, automation of batch and continuous pan, centrifugal control, dryer control, Pump Control, automation of injection and spray system.

**Reference:**

7. Mechanical Measurements – T G Beckwith, Roy D M & J H Lienhard
8. Instrumentation Devices & Systems – Rangan, Sarma & Mani
9. Industrial Instrumentation and Control - S K Singh
10. Principles of Industrial Instrumentation – D Patranabis
11. Industrial Instrumentation by Donald Eckman, Allied Publishers, 1982
12. Industrial Instrumentation and control by S.K Singh, 12<sup>th</sup> edition, Tata McGraw Hill Publishing Company Ltd., New Delhi.
13. Automatic Process Control by Donald P.Eckman, 6<sup>th</sup> edition, Wiley Eastern Limited.
14. Computer Control of Processes by M Chidambaram, Narosa Publishing House.
15. Perry's Chemical Engineering Hand book, 7<sup>th</sup> edition, Robert H.Perry, McGraw Hill Book Company, Singapore – 1997.
16. Process Modeling, Simulation and Control for Chemical Engineers by Luyben, McGraw Hill Kogakasha Ltd.
17. Chemical Process Control by George Stephanopoulos, PHI learning PVT Ltd.

**FOURTH SEMESTER**

**HARD CORE**

**COURSE-I: Manufacture IV - Finishing Operations**

**Course Outcomes**

After completion of this practical class, the students will be able to :

- Crystallization, drying, packing

**Pedagogy**

- Lecturing through PPT and demonstrations are the major methods used.
- Hands-on method is used to demonstrate factory aspects
- Learning through exploring the past research work in their specified fields.
- Factory visits, assignment and seminars.

**COURSE CONTENT**

**Crystalliser:** Crystallisation while cooling, air cooled & water cooled crystalliser, cooling and reheating of massecuite, transient heater, molasses exhaustion, saturation temperature, mechanical details of crystalliser drive, receiving crystalliser, pumping of massecuite. Vertical crystallizer – Construction, Working, advantages & disadvantages, Oscillating Vertical Cooling Crystallizer (OVCC).

**Centrifugal:** 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, storage of final molasses.

**Drying:** Characteristics of sugar, specifications of white sugar, sugar standards, 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 bins,.

**Packing:** Weighing, Bagging and retail packaging of sugar, specification of gunny bag.

**Storage:** Keeping quality of sugar, safety factor, storage conditions in godown, construction of godown.

9. Principles of Sugar Technology Vol. 2 - Peter Honig
10. Cane Sugar Handbook - D P Kulkarni
11. Handbook of Cane Sugar Technology – R B L Mathur.
12. Introduction to Cane Sugar Technology – G H Jenkins.
13. Hand Book of Cane Sugar Engineering – E Hugot
14. Introduction to Sugar Technology – Chen & Chou
15. Training Manual for Sugar Factories – Mangal Singh
16. Efficient Management of Sugar Factories – Mangal Singh

## **COURSE-II: EQUIPMENT CAPACITY**

### **Course Outcomes**

After completion of this practical class, the students will be able to :

- What are the factors needed to commence the factory
- Layout of the factory
- Calculation of number of unloader, size of feeder table cane carrier, mills, juice flow meter, heaters, evaporators, clarifiers, pans, crystallizer, centrifugals, dropper, bagging machine, godown, molasses storage tank, boiler heating surface.

## Pedagogy

- Lecturing through PPT and demonstrations are the major methods used.
- Hands-on method is used to demonstrate factory aspects
- Learning through exploring the past research work in their specified fields.
- Factory visits, assignment and seminars.

## COURSE CONTENT

**UNIT-I: 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, Zero<sup>th</sup> mill & last mill. Capacity of juice transfer pumps, Power required for preparatory devices, cane carriers and mills, mill drive (electric & hydraulic).

**UNIT-II: 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-III: 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-IV: Pan, Crystalliser & Centrifugals:** Capacity of supply tanks, capacity of batch & continuous pans by massecuite % cane & solid balance methods, S/V ratio, capacity of crystallisers – batch and continuous vertical crystallisers.

**Centrifugals:** Equation for Centrifugal force & gravity factor, number of machines required; fore workers and after workers for curing different massecuites, power requirement of centrifugals. Capacity of pug mills, magma minglers, molasses run-off tanks and molasses/magma/massecuite pumps. Capacity of hopper, conveyor, 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

## COURSE-III: CHEMICAL ENGINEERING III (MASS TRANSFER)

### Course Outcomes

After completion of this practical class, the students will be able to :

- Mass transfer operations, gas laws, crystallizers evaporators calculations and design

### **Pedagogy**

- Lecturing through PPT and demonstrations are the major methods used.
- Hands-on method is used to demonstrate factory aspects
- Learning through exploring the past research work in their specified fields.
- Factory visits, assignment and seminars

### **COURSE CONTENT**

#### **Unit I**

**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 & Mass Transfer:** Molecular diffusion & eddy diffusion, Reynolds analogy.

#### **Unit II**

**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 III**

**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, **Conveyors:** types of conveyers, conveyers used in sugar industry.

### **Reference**

1. Chemical Engineering, Vol 1,2 & 3 - Coulson & Richardson.
2. Unit Operations of Chemical Engineering – McCabe, 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 Banchemo
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 Chattopadhyaya



## **COURSE-IV: SUGAR TECHNOLOGY PRACTICAL –III**

### **Course Outcomes**

After completion of this practical class, the students will be able to :

- Determine colour, size, pol, moisture, ash of sugar

### **Pedagogy**

- Experimental demonstrations are the major methods used.
- Hands-on method is used to demonstrate field aspects
- Learning through exploring the past research work in their specified fields.
- Factory samples are also used.

### **COURSE CONTENT**

1. Determination of crystal size in Slurry and Masecuite.
2. Determination of Coefficient of Variation (Cv) in Sugar and Slurry
3. Determination of Pol% and Moisture% of sugar and calculation of safety factor
4. Determination of sulphited ash and conductivity ash in sugar
5. Determination of the colour of the sugar by ICUMSA GS-2/3-10 and GS-2/3-9 methods
6. Determination of SO<sub>2</sub> content in sugar
7. Determination of Starch in sugar
8. Determination of Dextran in Sugar by Haze Method
9. Flocc Test of Sugar
10. Determination of Reducing Sugar in Sugar by Luff's Method
11. Determination of Phenolic content of sugar
12. Determination of Iron in Sugar
13. Determination of Turbidity of Sugar
14. Determination of grade of the sugar by standard sieves and colour by standard sugar bottles
15. Analysis of Jaggery / Gur ( Purity, Reducing Sugar, Net Rendement)
16. Determination of Total Solids and Suspended Solids in Molasses
17. Determination of Fermentable and Un-fermentable sugars in Final molasses and B - Heavy Molasses
18. Determination of organic volatile acids in Molasses

### **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.



## SOFT CORE

### COURSE-V: ALLIED SUGAR MANUFACTURE AND BYPRODUCTS

#### Course Outcomes

On the completion of units of the course contents the students must be able to know about

- Bagasss, composition, uses.
- Power generation from bagass, molasses characteristics and manufacturer of alcohol and other chemicals from molasses.
- Diversion of B-heavy molasses for the production of alcohol
- Raw, refined sugar manufacture, jaggary manufacture Khandasari sugar manufacture

#### Pedagogy

- Lecturing through PPT and demonstrations are the major methods used.
- Learning through exploring the past research work in their specified fields.
- Factory visits, assignment and seminars.

### COURSE CONTENT

#### Allied Sugar Manufacture

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

**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.

**Specialty Sugars:** Brief description of manufacturing process of sugar cubes, liquid sugar, brown sugar, natural sugar granules (molasses & honey), Demerara sugar, castor sugar, icing sugar, fortified sugar, rock candy & caramel. Introduction to Sweeteners other than Sucrose (Saccharin, Sugar alcohols such as Sorbitol, Mannitol and Xylitol, Aspartame, Stevioside and Sucralose).

**Beet Sugar:** Introduction to beet sugar industry, agro-climatic conditions 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, beet diffusion, clarification and other manufacturing processes, specification of beet sugar.

#### Byproducts of Sugar Industry

**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, Juice/Syrup/B Heavy Molasses as raw material for 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

**COURSE-VI: INDUSTRIAL MANAGEMENT**

**Course Outcomes**

On the completion of units of the course contents the students must be able to know about

- Different types of ownership in industry.
- Scientific management
- Develop the traits required for entrepreneur
- Better knowledge about decision making communication
- Better human resource management and industrial acts.
- Men, material and finance management
- Quality management systems, safety, health and environment

**Pedagogy**

- Lecturing through PPT and demonstrations are the major methods used.
- Learning through exploring the past research work in their specified fields.
- Factory visits, assignment and seminars.

**COURSE CONTENT**

**Unit I**

**Forms of Business Organization:** Introduction, duties and responsibilities of organisation, types of business organisation (private companies, partnership organization, joint stock companies, private and public limited company - applications, advantages, disadvantages. Raising finance for joint stock company, cooperative societies. State ownership – Government Departmental organisations - public corporations - liabilities, distinctions, limitations between various forms of organisations. Criteria for setting up of sugar factory, statutory approvals, laws governing sugar industry.

**Administrative & Management Structure:** Definition of administration, duties and responsibilities of management, Chain of command, delegation of authority & responsibility, line - staff organisation, financial organisation, management structure in sugar industry.

**Unit II**



**Human Resource Management:** Introduction to HRM, duties of HR Manager, Staff recruitment procedure, training, discipline, motivation, safety, industrial psychology, welfare, personnel administration with reference to sugar factory (time keeping, labour turnover, absenteeism). Social Responsibility of Organisation – CSR initiatives.

**Industrial Acts:** Introduction and brief Description various industrial acts (Indian Factories Act – 1948, Indian Electricity Act – 1910, Indian Electricity Rule – 1956, Indian Boiler Act – 1923, Industrial Disputes Act, Workmen’s Compensation Act – 1923, Employee’s State Insurance Act – 1948, Payment of Wages Act - 1936, Trade Union Act – 1926)

### Unit III

**Materials Management:** Methods of purchasing (raw material, machineries & spares), stores & store keeping, system of location of materials, procedure for issue & return, spare parts management, inventory control, Management information systems & ERP.

**Finance Management:** Elements of cost - calculation of different costs with examples (Material, Labour, Fixed, Variable), depreciation, methods of calculating depreciations – interest on capital, idleness, maintenance- equipment replacement policy, loss & profit, budgetary control.

### Unit IV

**Production Management:** Definition of Productivity, factors affecting productivity, measures to improve productivity, factory lighting.

**Quality Management Systems & SHE (Safety, Health & Environment):**

Introduction to Quality Management Systems (QMS) – ISO 9001, Food Safety Management Systems (FSMS) – ISO 22000, Hazard Analysis and Critical Control Point (HACCP), Good Hygienic Practices (GHP), Good Manufacturing Practices (GMP), Environmental Management Systems – ISO 14001 and Laboratory Management Systems – ISO 17025

## COURSE-VII: ADD ON PROFICIENCY COURSE: IN-PLANT TRAINING IN A SUGAR FACTORY - 4 MONTH

### Course Outcomes

On the completion of units of the course contents the students must be able to know about

- To develop creative talents in the students
- Training work should be useful to students
- To give the students a taste of real life problem solving and thus simulate industrial environment with the Master’s degree
- To develop those abilities that cannot be developed by normal classroom situations such as group work, sharing responsibilities, hands on experience etc.

### Pedagogy

- Students will undergo a rigorous training in the sugar factory for four months in different months of two each. He will stay in the factory working in all three shifts with a specified work schedule.

## COURSE CONTENT

### LABORATORY PRACTICE

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

Production of SO<sub>2</sub>: 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<sub>2</sub> 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, vacuum trouble, want of crystalliser, 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.

*K.S. Kumar*  
CHAIRMAN  
BOS in Sugar Technology  
University of Mysore  
Sir. M. Y. Shiveswaraiah P.G. Centre,  
Mandya - 571402