SOLID FLUID OPERATION **Course Code : 312342**

Programme Name/s : **Chemical Engineering**
Programme Code : **CH**
Semester : **Second**
Course Title : **SOLID FLUID OPERATION**
Course Code : **312342**

I. RATIONALE

Solid fluid operation deals with the handling & transportation of fine, coarser material. The main objective of this course is particle characterization, size reduction, handling of dry material with or without fluid. After completion of this course, students understand the concept of separation of gas-solid, solid-solid, liquid-solid.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the student to attain the industry identified competency through various teaching learning experiences:

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Use different size reduction equipment such as Jaw crusher, Hammer mill, Ball mill etc. in given chemical process industry.
- CO2 - Use the relevant separation methods for solid-solid separation.
- CO3 - Select the relevant method for solid-liquid separations.
- CO4 - Select the appropriate method to separate gas-solid mixture.
- CO5 - Apply the knowledge of mixing/agitation in given chemical process industry.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme												
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical							
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
312342	SOLID FLUID OPERATION	SFO	DSC	4	-	4	2	10	5	3	30	70	100	40	50	20	25@	10	25	10	200

Total IKS Hrs for Sem. : 0 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Describe with sketches the relevant measurement technique for the given solid particle. TLO 1.2 Calculate the power requirement for size reduction of given solid particle. TLO 1.3 Describe the construction & working of given size reduction equipment. TLO 1.4 Enlist the factors affecting the size reduction of the given solid. TLO 1.5 Explain different types of conveyor in various chemical industries.	**Unit - I Properties of Solids and Size Reduction** 1.1 Characterization of Solids: Particle shape, size. Concept of Sphericity. 1.2 Size Reduction : Importance of size reduction, factors affecting on size reduction. Kick's Law, Rittinger's law, Bond's law, Work index, Crushing efficiency & power consumption. Numerical. 1.3 Classification of size reduction equipment. Concept of open & closed circuit grinding. 1.4 Size reduction equipment: Principle, construction & working of Jaw crusher, Gyratory crusher, Roll mill. Grinder: Hammer mill, Ball mil (Concept of Critical speed of Ball mill with derivation) Numerical. 1.5 Conveyor : Importance of conveyor, Belt conveyor, Chain conveyor, Screw conveyor & Pneumatic conveyor.	Chalk-Board Demonstration Case study Presentations

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Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 Describe the cumulative and differential analysis method for screening TLO 2.2 Identify the relevant equipment for screening operation . TLO 2.3 Describe with sketches the process of flotation for the given mixture. TLO 2.4 Describe with sketches the Electromagnetic separation for the given system of mixture	**Unit - II Solid-solid Separation** 2.1 Screening: Concept of operation, Mesh Number, Oversize and undersize particle, cut diameter, Ideal and Actual screen 2.2 Types of standard Screen Series: Tyler standard screen series, Indian standard screen series, Capacity and Screen Efficiency, Types of screen analysis: Differential and cumulative. Factors affecting screening operation. 2.3 Screening Equipment: Concept & operation i) Vibrating screens ii)Flip Flow screens iii)Gyratory screens 2.4 Froth Flotation: Mechanism,floating agents,Industrial floating equipments. 2.5 Electromagnetic separation: Magnetic Drum separator Principle, construction, working, industrial application	Chalk-Board Demonstration Case Study Site/Industry Visit
3	TLO 3.1 Apply principle of Filtration for separation in given chemical industry. TLO 3.2 Apply the principle of centrifugation for given mixture TLO 3.3 Perform batch sedimentation test for given operation. TLO 3.4 Explain working of relevant sedimentation equipment	**Unit - III Solid-Liquid Separation** 3.1 Filtration: Principle, Types, Factors affecting filtration rate, filter aid ,filter media 3.2 Types of filtration equipments a) Primary filter – Sand filter (pressure sand filter and rapid sand filter) b) Pressure filters – Plate & frame filter press (Washing type & Non washing type) c) Vacuum filter – Rotary drum filter d) Centrifugal filter – Basket 3.3 Sedimentation: Concept, Free and Hindered settling velocity, Batch sedimentation test, Factors affecting the rate of sedimentation 3.4 Dorr Thickener, Clarifier, Settling Tank: Principle, Construction and Working.	Chalk-Board Demonstration Case Study Presentations Site/Industry Visit
4	TLO 4.1 Describe with sketches the construction & working of cyclone separator for given gas-solid mixture. TLO 4.2 State principle and applications of Electrostatic separator. TLO 4.3 Explain with sketches working of Fabric filter for given gas-solid mixture TLO 4.4 Identify relevant wet scrubbers for the given gas-solid mixture. TLO 4.5 Describe gravity settling tank for separation in given chemical industry.	**Unit - IV Solid-Gas Separation** 4.1 Cyclone separator: Principle, construction, working &industrial applications 4.2 Electrostatic separator: Principle, construction, working & industrial applications 4.3 Fabric filter: Principle, construction & working, & industrial applications 4.4 Wet scrubber (Simple wet scrubber, venturi-scrubber): Principle, construction & working, & industrial applications 4.5 Gravity settling Tank: Principle, construction & working.	Chalk-Board Demonstration Case Study Presentations Site/Industry Visit

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
5	TLO 5.1 Explain importance of mixing & agitation. TLO 5.2 Compute the mixing index for given system. TLO 5.3 Draw the various flow pattern such as radial, axial. TLO 5.4 Describe the concept of swirling & vortexing.	**Unit - V Mixing of Solids and Fluids** 5.1 Importance of mixing & agitation: Principle of mixing. 5.2 Criteria for selection of agitator: Propellor, turbine, paddles. 5.3 Concept of swirling & vortex: Methods of prevention of swirling & vortex formation. 5.4 Mixers: Concept of mixing index. Principle, construction & working of Sigma mixer, Ribbon blender.	Chalk-Board Demonstration Case Study Presentations Site/Industry Visit

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Explain basic operation of jaw crusher. LLO 1.2 Calculate particle size distribution	1	* Calculate the efficiency of Jaw crusher for given material.	4	CO1
LLO 2.1 Explain basic operation of Hammer mill/Pulverizer LLO 2.2 Calculate particle size distribution	2	Calculate the efficiency of Hammer mill for given material.	4	CO1
LLO 3.1 Explain the working of ball mill. LLO 3.2 Analyze the effect of change of residence time on grinding.	3	* Calculate the efficiency of ball mill for given material.	4	CO1
LLO 4.1 Describe the concept of centrifuging of ball mill. LLO 4.2 Compare operating speed & critical speed of ball mill.	4	* Calculate the critical speed of ball mill.	4	CO1
LLO 5.1 Explain the solid-solid separation technique based on size. LLO 5.2 Evaluate the efficiency of screen in separating the solid particles	5	* Calculate effectiveness of screen for given system.	4	CO2
LLO 6.1 Explain the solid-solid separation technique LLO 6.2 Enlist the factors affecting the screening operation	6	Use Vibrating Screen/Sieve Shaker/Flip flow screen for separation of given solid mixture.	4	CO2
LLO 7.1 Explain the solid-solid separation technique based on surface properties. LLO 7.2 Compare different frothing agents, promoters and collectors	7	* Calculate % recovery of coal in froth from coal-sand mixture by using Froth Flotation cell	4	CO2

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 8.1 Explain the solid-solid separation technique based on magnetic properties. LLO 8.2 Describe the operation of drum separator.	8	Calculate % recovery of magnetic material by using magnetic Drum separator.	4	CO2
LLO 9.1 Explain the concept of filtration. LLO 9.2 Describe the working of Plate and Frame filter press.	9	* Calculate % recovery of filtrate collected for given system using Plate & Frame filter.	4	CO3
LLO 10.1 Explain the concept of vacuum filtration. LLO 10.2 Explain the working of Rotary drum filter.	10	* Plot the filtration curve using vacuum filter.	4	CO3
LLO 11.1 Explain the separation of solids from suspension under gravity. LLO 11.2 Calculate free settling of particle in given suspention.	11	* Perform the batch sedimentation test by using different concentrations of calcium carbonate slurry (<5%weight) and find terminal settling velocity.	4	CO3
LLO 12.1 Explain the separation of solids from suspension under gravity. LLO 12.2 Describe the concept of hindered settling conditions.	12	Perform the batch sedimentation test using different concentration of calcium carbonate (>5%weight)slurry and find terminal settling velocity.	4	CO3
LLO 13.1 Explain the separation of solids from suspension by application of centrifugal force. LLO 13.2 Describe the operation of basket centrifuge.	13	* Calculate % recovery of solid from given slurry by using basket centrifuge.	4	CO3
LLO 14.1 Describe the separation of solids from gas by application of centrifugal force. LLO 14.2 Explain the working of cyclone separator	14	* Calculate % separation efficiency of Cyclone Separator for given solid-gas mixture.	4	CO4
LLO 15.1 Explain the concept of mixing. LLO 15.2 Describe the operation of ribbon blender	15	* Use ribbon blender for finding mixing index for granular solids.	4	CO5
LLO 16.1 Explain the concept of mixing. LLO 16.2 Explain the operation of sigma mixer.	16	* Use Sigma mixer for finding out mixing index .	4	CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING /

SKILLS DEVELOPMENT (SELF LEARNING)

Assignment

- 1. Classify the size reducing equipment. 2. Calculate the power required for crushing the solids.(various numerical) 3. Suggest the different methods of separation of solids. 4. Enlist the industrial applications of different conveyors.

Micro project

- 1. Visit the nearby industry to study mechanical operations. 2. Prepare a chart showing classification of size reducing equipment with their neat sketches. 3. Prepare model of Belt/screw/bucket conveyor. 4. Prepare model of plate and frame filter. 5. Prepare a laboratory scale sand filter. 6. Prepare a simple water filtration model. 7. Prepare a model for separating magnetic and non-magnetic materials. 8. Fabricate a Grizzly with various sized screen apertures. 9. Collect the solids of different sizes and shapes from nearby industries.

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Blake Jaw Crusher :3HP Motor 2.2 kW	1
2	Set of sieves	1,2,3,5
3	Sieve shaker/Vibrating Screen/Flip flow screen	1,2,3,6
4	Vacuum filter	10
5	Measuring cylinder of one lit capacity	11,12
6	Basket Centrifuge 3HP Motor 2.2 kW	13
7	Cyclone Separator	14
8	Ribbon Blender	15
9	Sigma Mixer 3HP Motor 2.2 kW	16
10	Hammer Mill/Pulverizer	2
11	Ball Mill DC Motor3HP Motor 2.2 kW	3,4
12	Froth Flotation Cell	7
13	Magnetic Drum Separator	8
14	Plate and Frame Filter press	9
15	Weighing Balance (Digital Display, 1kg, Sensitivity. 0.1 g)	All
16	Stop Watch (Analogue)	All

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

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Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Properties of Solids and Size Reduction	CO1	14	4	6	6	16
2	II	Solid-solid Separation	CO2	12	4	4	4	12
3	III	Solid-Liquid Separation	CO3	16	4	6	6	16
4	IV	Solid-Gas Separation	CO4	8	4	4	6	14
5	V	Mixing of Solids and Fluids	CO5	10	4	4	4	12
Grand Total				**60**	**20**	**24**	**26**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Each practical will be assessed considering : 60 % weightage to process. 40 % weightage to product

Summative Assessment (Assessment of Learning)

- End of Term Examination (Lab. performance),Viva-voce

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	02	02	02	01	02	01	02			
CO2	02	02	01	01	02	01	02			
CO3	02	02	01	02	02	01	02			
CO4	02	02	01	02	02	01	03			
CO5	02	02	01	02	02	01	02			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	McCabe W, J. Smith, J.C. , Peter Harriott	“Unit operations of Chemical Engineering “	McGraw-Hill international - 7 th Ed. ISBN 978-8184959635
2	Coulson and Richardson’s	“Chemical Engineering Vol. - 2B“ Separation Processes	Butterworth-Heinemann ISBN 978-0081010976
3	Badger,L.W.Banchero,T.J.	“Introduction to Chemical Engineering”	McGraw Hill Publication ISBN 978-0074630501

Sr.No	Author	Title	Publisher with ISBN Number
4	Anup K. Swain, Hemlata Patra, G. K.Roy	“Mechanical Operations “	McGraw Hill Publication ISBN 978-0070700222
5	C.M.Narayan , B.C. Bhattacharya	“Mechanical Operations for Chemical Engineers”	Khanna Publishers ISBN 978-8174090362

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.youtube.com/watch?v=Y1_mr09prfY	Types of Jaw Crusher
2	https://www.youtube.com/watch?v=ldhRvlU1G70&t=21s	Working of Ball Mill
3	https://www.youtube.com/watch?v=-BHmsjvnm_4	Working of Hammer Mill
4	https://www.youtube.com/watch?v=EfTcfQY4kEY	Working of Plate & Frame filter press
5	https://www.youtube.com/watch?v=npiTNdapr7w	Working of Conveyor
6	https://www.youtube.com/watch?v=fHj8djUc3og	Description of Cyclone seperator
7	https://www.youtube.com/watch?v=E2Ln8KgrhpA	Froth Flotation Process
8	https://www.youtube.com/watch?v=N2f5X1wkbvQ	Different types of Mill
9	https://www.youtube.com/watch?v=e0i3mxc79yI	Sigma Blade Mixer

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students