

Course Structure and Syllabus for 2-year 4-semester M. Tech. Course in Ceramic Engineering

(With effect from Academic year 2024-2025)

1st Semester:

Paper No	Sub Code	Subject	Periods			Cr	Marks		
			L	T	P		IA	UE	TM
Theory									
I	CHT101	Process Modelling and Simulation	3	1	-	4	30	70	100
II	CER102	Ceramic Science and Technology	3	1	-	4	30	70	100
III	CER103	Refractories & Structural Ceramics	3	1	-	4	30	70	100
Practical									
IV	CHT104	Computer Application in Chemical Industries	-	-	8	4	60	40	100
V	CER105	Chemical & Instrumental Analysis	-	-	8	4	60	40	100
		Total	9	3	16	20	310	290	500

2nd Semester:

Paper No	Sub Code	Subject	Periods			Cr	Marks		
			L	T	P		IA	UE	TM
Theory									
VI	CHT201	Optimization	3	1	-	4	30	70	100
VII	CER202	Glass and Vitreous Coating	3	1	-	4	30	70	100
VIII	CER203	Electrical and Electronic ceramics	3	1	-	4	30	70	100
IX	CER204	Advanced clay-based ceramics and Ceramic Machines	3	1	-	4	30	70	100
Practical									
X	CER205	Ceramic Engineering Laboratory: Synthesis & Characterisation of ceramic materials	-	-	8	4	60	40	100
		Total	12	4	8	20	180	320	500

3rd Semester:

Paper No	Sub Code	Subject	Periods			Cr	Marks		
			L	T	P		IA	UE	TM
XI	CHT301	Research Methodology	-	2	-	2	15	35	50
XII	CER302	a. Project Feasibility – Report	-	2	8	6	90	60	150
		b. Project Feasibility – Viva Voce	-	-	-	4	-	100	100
XIII	CER303	Mini Project with seminar	-	4	-	4	-	100	100
XIV	CER304	Thesis: Foundation	-	-	-	4	-	100	100
		Total	-	8	8	20	105	405	500

4th Semester:

Paper No	Sub Code	Subject	Periods			Cr	Marks		
			L	T	P		IA	UE	TM
XV	CER401	a. Thesis: Final-Report	-	4	16	12	-	-	300
		b. Thesis: Final-Viva Voce	-	-	-	4	-	100	100
XVI	CER 402	General Viva Voce	-	-	-	4	-	100	100
		Total	-	4	16	20	-	500	500

Total Credit Point: 20 + 20 + 20 + 20 = 80; **Grand Total:** 2000

IA: Internal Assessment; UE: University Examination; TM: Total Marks

SYLLABI OF 2 YEARS (FOUR SEMESTER) M.TECH. COURSE IN CERAMIC ENGINEERING.

First Semester

Paper I

Course CHT 101

100 Marks/ 4 credits

Process Modeling & Simulation

Module 1: Mathematical Modeling Fundamentals: Art of modeling, laws, assumptions, degrees of freedom, consistent modeling, synthesis, analysis and optimization. General purpose modeling, specific purpose modeling, scientific modeling, engineering modeling.

Module 2: Models of equipment, unit operation/unit process; material & energy balance, property relations, Constraints, steady state and unsteady state models. Specific Equipment Design models: Batch reactor, continuous tank reactor, Continuous tubular, catalytic reactor, heat exchanger, Distillation column.

Module 3: Plant modeling, stream variable and stream properties, tear stream and tear variable, modular approaches: sequential, simultaneous and equation solving approaches. Sequencing and ordering of solving equations.

Plant modeling: A plant with/without a recycle stream, plant with controlling elements.

Module 4: Solution algorithm and flow chart development for various mathematical models.

Computer simulation: Programming languages, sequences and algorithm development.

Specific simulators: Binary distillation column, Heat exchanger, reactor, flasher.

Plant flowsheeting: Three CSTR in series, Propylene dimerization plant, sulfuric acid plant, etc.

Paper II

Course CER 102

100 Marks/ 4 credits

Ceramic Science and Technology

Module 1: Structure of ceramic solid-crystalline solids and their defects, non-crystalline solids, multiphase materials. Physical principles of ceramic processes, diffusion, solid state reaction, sintering and related phenomena.

Ceramics microstructure: nucleation, grain growth transformation, sintering methods and mechanisms, control of microstructure. Application in advanced ceramics systems like toughened ceramics, silicon nitrides, sialons etc.

Technological aspects of advanced ceramic materials viz. Ceramic-matrix composites, Ceramic membranes, Solid oxide fuel cell, Cermets, Bioceramics, Ceramics in nuclear field.

Module 2: Mechanical properties of ceramics: Modes of failure fracture, fatigue and creep mechanisms of failure, theoretical fracture strength, Griffith flaws in brittle failure, nucleation and propagation of microcracks. Viscous and Viscoelastic behavior. Strengthening methods, composite materials, FRP's.

Thermal properties of ceramics, thermal expansion, heat capacity and thermal conductivity. Thermal behaviour and microstructure, thermal stresses and deformations. Electrons in solid-

band theory, semi-conductors and devices, semiconductor materials. Preparation of single crystals and simple devices, MOS, Zone melting techniques.

Dielectrics, their properties and characterization, ceramic dielectric materials, ferroelectric ceramics, magnetic materials-origin of magnetism, classification of magnetic materials, ferrites, and related materials, ceramic super conductors. Optical properties of glasses and ceramics, optical materials, luminescence, lasing action and fibre communication.

Paper III

Course CER 103

100 Marks/ 4 credits

Refractories and Structural Ceramics

Module 1: Pure oxide Refractories – Magnesia, Alumina, zirconia, Beryllia and Thoria. Mullite and mullite containing Refractories. Spinel and Spinel containing refractories. Graphites – evaluation, natural and artificial. Different types of composites refractories, Refractory metals, Cermets. Fabrication and properties of these refractories.

Non oxide refractories – their structure, preparation, properties, applications and evaluation and microstructures. Carbides, Nitrides, Silicides and Borides, fabrication and properties of Sialon and Sialon Composites. Fabrication and properties of these refractories.

Module 2: Different types of castables, plastics, gunning materials and their application in steel plants. Application of nanomaterials in refractory castables. Particle size distribution and firing practice of monolithic refractories. Phase diagrams of important refractory/ceramic systems.

Paper IV

Lab – I

Course CHT 104

100 marks/4 credits

Computer Application in Chemical Industries

Writing computer program to solve complex design and modeling problems like heat exchangers, flashers, reactors, distillation columns, plant simulation problems etc.

Paper V

Lab – II

Course CER 105

100 marks/4 credits

Chemical and Instrumental Analysis

Analysis of trace elements in ceramic materials by spectroscopic analysis – AAS, UV-VIS, Flame Photometry etc.

Analysis of Lithium bearing materials. Direct estimation of different constituents in Portland Cement. Analysis of some high performance refractory materials — sintered mullite, Brown and White Tabular alumina, Zircon, Silica in silicon carbide. Analysis of some synthetic hydrogel, Dead burnt magnesite. Estimation of different constituents in dehydroxylated clays.

Chemical analysis of some redox systems in ceramic materials: $\text{Fe}^{+2} \text{ — } \text{Fe}^{+3}$,

$\text{Cr}^{+3} \text{ — } \text{Cr}^{+6}$, $\text{Cu}^{+} \text{ — } \text{Cu}^{+2}$, $\text{Mn}^{+2} \text{ — } \text{Mn}^{+7}$. Thermal analysis: Differential thermal and Differential thermo- gravimetric analysis of ceramic raw materials and products.

Second Semester

Paper VI

Course CHT 201

100 marks/4 credits

Optimization

Module 1: Introductory concepts : Objective function, single valued function, multivalued function, non-linear function, linear function, stationary point, relative and absolute extreme, convex, concave and unimodal functions, gradient reduction method, jacobian and hessian matrix.

Module 2: Optimization of univariate system using analytical method. Search techniques, quadratic interpolation, cubic interpolation. Optimization of multivariate unconstrained system using.

Module 3: Search techniques. First order methods and second order methods. Optimization of multivariate constrained systems using Lagrange multipliers, penalty function, linear programming and non-linear programming.

Module 4: Computer programming of optimization of specific problems related with chemical industry.

Paper VII

Course CER 202

100 marks/4 credits

Glass and vitreous coating

Module 1: Concept of vitreous state, kinetics of high temperature reactions during glass formation. Different glass forming systems and their stability. Phase transformation in glass-crystallisation and glass formation, controlled crystallisation in glass ceramics, liquid-liquid phase separation. Conventional glass fabrication process. Glass formation by sol-gel processes and their application.

Coloured glasses- Redox distribution, Anionic substitution in glass, Absorption spectra of transition metal ions. Radiation shielding of glass, IR absorbing and reflecting glasses. Surface tension, optical & electrical properties, strength of glass, toughening of glass. Glass durability: Mechanism of reactions of glasses with aqueous solutions.

Module 2: Photosensitive and photo conducting glasses. Chalcogenide glass, metallic glass, damage tolerant glass, laser glasses and its application and bio-glasses. Glass-ceramics: glassceramics armour, radioactive waste disposal glasses, machinable glass-ceramics.

Concept of adhesion of vitreous coatings on metal surface. Physico-chemical characteristics of metals and alloys suitable for enamelling. Opacification of glass and its mechanism. Enamelling of gold, silver, copper and other alloys. Deposition of films and high temperature coatings-different method of application and heat sources.

Paper VIII

Course CER 203

100 marks/4 credits

Electrical and Electronic Ceramics

Module 1: Insulator Porcelain: high and low tension, constitution and translucency of porcelain. Ceramic colours and stains. Steatite, Cordierite and Lithia Ceramics, Ceramic Insulators. High permittivity Ceramics, Ceramic Substrates, Piezoelectric and Pyroelectric Ceramics, Ferroelectric ceramics and devices, Application and characterization of Varistors, Electro-optic Ceramics, Ceramic Semiconductors, packaging of semiconductor devices.

Module 2: MEMS, integrated circuits, obstacles to integration – thermal, chemical and mechanical factors, overview of other functional devices. Thin film technology, polycrystalline conducting thin films. Deposition and properties of insulating film. Materials for solar cells. Failure analysis, structure and composition of microelectronic materials, Capacitor Ceramics, Ferromagnetic Ceramics, Magnetic recording media, High temperature super conducting ceramics. Metallized Ceramics, Multilayer ceramics, various Sensors and their application.

Paper IX

Course CER 204

100 marks/4 credits

Advanced clay-based ceramics and Ceramic Machines

Module 1: Structures, Properties associated with different types of atomic bonds. Geology of clays. Mixed layered minerals, Chlorites, Attapulgite and Palygorskite. Size and shape of the clay minerals. Factors determining the shape and size in the genesis and diagnosis of clay minerals. Identification and Separation of clay minerals. Electrometric processes, X-ray and infra red method of analysis.

Plasticity of Clays: Relationship with the structures, Different theories relating to plasticity. Rheological behaviour of clays and clay based system: Reiner Rivlin equation. Classification of flow system. Different types of multipoint consistency curves. Thixotropic systems and the flow behaviour. Stability of clay Suspensions: Mechanism of peptization, Role of interaction with the aqueous phase. Particle association in clay suspensions. Technical applications of stability control. Interaction of clay organic compounds.

Nanoclays, Clay-polymer-composites, Layered double hydroxides, Modification of clays and clay minerals properties by thermal, physical and chemical treatments, Synthesis of novel materials (such as zeolites, geopolymers etc.) starting from clay minerals.

Module 2: Equipment of size reduction and grading of ceramic materials. Different types of static and dynamic mixing equipments. Pressure fabrication Machines: Different types of semi-automatic and automatic presses. Vibratory compaction machines. Iso-static and Hot isostatic pressing. Extrusion and pugging machines.

Different types of driers and their design. Machineries used for semi-automatic and automatic fabrication of glass articles. Kilns and Furnaces: Continuous glass tank furnaces, Down and Updraft Kilns, Chamber and Hoffman Kilns, Tunnel Kiln, Rotary Kiln.

Paper X**Lab – III****Course CER 205****100 marks/4 credits****Ceramic Engineering Lab*****Synthesis & Characterisation of ceramic materials***

Processing of some ceramic precursors: Refractory applications of synthetic hydrogels, co-precipitation and sol-gel techniques for ceramic powder preparation. Compaction of single and multicomponent precursors, sintering behavior of fabricated composites. Value added ceramic materials from industrial wastes- fly ash, blast furnace slag, red mud and phospho-gypsum. Preparation of special glasses and glass-ceramics.

Bulk density, Apparent porosity and true porosity. Reheat shrinkage and thermal shock resistance of refractories. Fired strength of some refractory castables. Static slag corrosion resistance of unshaped refractories. Glass-aqueous phase reaction in presence of different solutions. Surface area and particle size distribution of ceramic materials. Determination of dielectric constant, Break-down voltage of ceramic insulator, capacitance. Cation exchange kinetics of clays and synthetic inorganic exchangers. Non-destructive testing of ceramic materials.

Microscopic studies (Optical, SEM, TEM etc.), FTIR, Ultrasonic Testing of ceramic materials.

Third Semester**Paper XI****Course CHT 301****50 Marks/2 credits****Research Methodology*****Module 1: Introduction:***

Definition of Research Methodology. Different types of methods for research. Approaches of investigation of solutions for research problem, Effective literature studies approaches, (Discuss in class Web Search: Introduction to Internet. Use of Internet and www. Using of search engines and advanced search tools.)

Data Collection and Simulation

Module 2: Data Analysis

Analysis tools: Review of Basic Statistical Measures (mean, median, mode, quartile, percentile, variance, covariance, correlation, regression), Probability Distributions (Binomial, Poisson, Uniform, Exponential, Normal), Central Limit Theorem, ANOVA, Latin Square Design, Sampling (Chi-square Distribution, F- Distribution), Test of Hypothesis.

Module 3: Reporting

Technical report writing, Technical paper writing, Plagiarism and citation. Major contribution, outcome of the research, patent possibilities. Patent writing, Patent filing, IPR

Introduction to presentation tool, features and functions, creating presentations, customising presentation using Microsoft PowerPoint, Open Office etc.

Introduction to spread-sheet applications, features and functions, using formulae and functions, data storing, features for statistical data analysis, generating charts/graphs and other features.

Paper XII

Course CER 302

(150+100) Marks/(6+4) credits

a) Project Feasibility

Each student shall be required to submit two bound type written copies of a project report on a proposed chemical plant manufacturing product/products related to one's course/subject to be worked out under the supervision of a faculty member. The report shall include mass and energy balances, type and capacity of equipment selected and recommended, plant layout, feasibility analysis highlighting market survey, pattern of assistance available from the central and state government agencies, bank and financial institutions. Assistance for technology, raw materials, finance.

Legal obligation.

b) The student is to appear in a **Viva-Voce** examination.

Paper XIII

Course CER 303

100 Marks/4 credits

Mini Project with seminar

Each student will be required to prepare and submit an essay or review paper on selected technological topic related to subject under the supervision of a faculty member. He/She shall give a talk based on his/her paper before the Seminar. The attendance in the seminar is compulsory for all the students.

Paper XIV

Course CER 304

100 Marks/4 credits

Thesis: Foundation

Each student shall be required to carry out under the supervision of Faculty member (s) and/or External member as the case may be, an original investigation on an industrial problem related to one's course/subject. She/he shall submit two typewritten bound copies of a report on Research Work at least 15 days before the commencement of final semester examination and shall defend her/his report in a Viva-voce Examination.

Fourth Semester

Paper XV

Course CER 401

(300+100) Marks/ (12+4) credits

Thesis: Final

- (a) Each student shall be required to carry out under the supervision of a faculty member original investigation on an industrial problem related to subject. He/She shall submit three type-written bound copies of thesis embodying the results of his/her investigations
- (b) The student shall defend his/her thesis in a **viva-voce** examination.

Paper XVI
Course CER 402
General Viva Voce

(100) Marks/ (4) credits

Each student shall be required to appear General Viva Voce Examination.