3.1 CERAMIC RAW MATERIALS

L	T	P
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RATIONALE

This subject has been designed to introduce the diploma holders to the properties related to the structure and the characteristics of various types of specialized materials used in the ceramic industries. The usage of these materials in various industries is also covered in this subject.

DETAILED CONTENTS

1. Plastic Raw Materials:- Introduction, Geology, mineralogy, classification of residual clay, transported Kaolin, Ball Clays, Stone ware Clay, fire clay, Alumina clays. Bentonite clay, their properties & use in ceramic industries. (10 hrs)
2. Non-clay Plastic raw materials:- Talc, steatite pyrophyllite (Agalamatolith) sericite pyrophyllite & their properties, use in ceramic industries. (06 hrs)
3. Non-Plastic raw materials:- Silica, Quartz, Sandstone, Ganister, Quartizite, Sand, Flint, Diatomite & their properties & use in ceramic industries.
   Feldspar, Cornish stone, Nepheline syenite, Pumic or Volcanic ash, Perlite, Bone ash, Apatite, Tricalcium Phosphate & their properties & use in ceramic Industry. (06 hrs)
4. Other Alumina & Silica Containing raw materials:- Silimanite, Kyanite, Andalusite & their properties & uses. (06 hrs)
5. Frit Making: Involving smelting, Quenching, Drying & milling. Study of furnaces related to enamel firing. Batch making of ground coat, cover coat enameling. (08 hrs)
6. Glaze:- Introduction, raw materials, properties of raw materials of glaze (including optical Properties like reflectance, opacity etc.), batch making, mixing, milling. (08 hrs)
7. Type of Glaze: Raw glaze, transparent glaze, opaque glaze, coloured glaze, matt glaze, lead glaze, leadless glaze, crystalline glaze etc.Opacifiers, colors, coloring oxide like iron oxide, cobalt oxide, copper, chromium, venedium, zircon etc. (10 hrs)
8. Enamels: Introduction, raw materials for enamels, its properties. Application method of Enamels & Glazes: Drying & brushing, spraying, dipping, pouring, screen printing etc. Decoration: Underglaze, onglaze, inglaze. (10 hrs)

INSTRUCTRIONAL STRATEGY

Students must visit various industries like White ware industries, Glass industries; refractory industries etc. to get exposure to various raw materials used indifferent ceramic industries.

RECOMMENDED BOOKS

1. The Science and Engineering of Materials by Donald R. Askeland,
2. Elements of Material Science and Engineering by Lawrence H. Vanvlack,
3. Material Science and Engineering by V Raghavan,
4. Ceramics, Mastering the Craft by Richard Zakin,

SUGGESTED DISTRIBUTION OF MARKS

Sr. No	Time Allotted (Hrs)	Marks Allotted (%)
1	10	16
2.	06	10
3.	06	10
4.	06	10
5.	08	10
6.	08	12
7.	10	16
8.	10	16
Total	**64**	**100**

3.2 MATERIALS SCIENCE

L	T	P
4	-	-

RATIONALE

This course has been intended to introduce the diploma holders to the properties related to the structure and the characteristics of various types of materials used in the ceramic industries. New materials are being developed & it is possible to change the properties of materials to suit the requirements. This course aims at developing knowledge on various types of materials.

DETAILED CONTENTS

1. Atomic structure and electronic configuration, types of bonds Space lattice and unit cell crystal system and indices, structure of ceramic material, X-ray, Bragg's law and use of X-ray for determination of cell structure. Point, line and Surface defects. Edge and Screw dislocation. (20 hrs)

2. Solid solution, Intermediate phases and intermetallic compounds, Gibbs phase rule. Uniary, Binary and Ternary phase diagrams, Lever rule. Phase transformation, nucleation and growth. Martensitic transformation. Examples: Water system, Al2O3-SiO2, Iron carbon diagram, Pb-Sn (20 hrs)

3. Hardening, Recrystallisation and Grain growth, Glass transition, Elastic behavior of materials. Strengthening, Ductile and Brittle fracture, Creep and Fatigue. Thermal properties of materials, Electrical, Electronic and dielectric behavior of materials (Conductance, resistance, permanence, insulation, dielectric constant impedance). Magnetic behaviour, Hard and soft magnetic properties, magnetic flux, flux density magnetizing force, permeability, coercive force, retentivity, remanence, refractive index. (24 hrs)

INSTRUCTRIONAL STRATEGY

The teachers should show different models of different crystal structures etc to have better understanding of the subject, by the students.

RECOMMENDED BOOKS

1. Material Science and Engineering by V Raghavan, Prentice Hall of IndiaPublishing
2. Material Science by Narula and Gupta
3. Engineering Materials by B.K. Agarwal
4. Material Science by R.K. Rajput; SK Kataria and Sons, Ludhiana
5. Introduction to Matrial Science for Engineers by J.F. Shackelford,
6. The Science and Engineering of Materials by Donald R. Askeland, PWS-Kent
7. Elements of Material Science and Engineering by Lawrence H. Vanvlack, Addison

SUGGESTED DISTRIBUTION OF MARKS

Sr. No	Time Allotted (Hrs)	Marks Allotted (%)
1	20	30
2.	20	30
3.	24	40
Total	**64**	**100**

3.3 UNIT OPERATIONS IN CERAMICS

L	T	P
5	-	4

RATIONALE

A thorough knowledge of unit operations is essential for the study of ceramic engineering. This course acquaints the students with the basic principles of fluid mechanics, mechanical operations, heat transfer, mass transfer and thermodynamics.

DETAILED CONTENTS

1. Fluid Mechanics (10 hrs)

- Properties of fluids
- Types of flow: Laminar and Turbulent, Newtonian and Non-newtonian fluids
- Concept of Bernoulli equation and its applications

2. Mechanical Operations (15 hrs)

- Size separation: Industrial screening equipment, Vibrating screen, Sieve analysis, Determination of particle size.
- Conveying: Belt conveyor, screw conveyor and chain conveyor
- Mixing: Dry mixer, paddle stirrer and wet mixer.
- Filtration: Batch and continuous filters- Plate and frame filter press, rotary drum filter
- Sedimentation: Batch and continuous equipments
- Agitation: objectives, types of agitation equipments

3. Mass transfer (15 hrs)

- Concept of diffusion, Fick's law, mass transfer coefficient, convective mass transfer
- Crystallisation: Rate of crystallization, purity of product, size of crystals, yield of given operation
- Principles of drying and drying equipments
- Introduction to humidification and dehumidification

4. Heat Transfer (20 hrs)

- Modes of heat transfer – conduction, convection and radiation
- Conduction through composite walls, Fourier's law, simple related problems
- Free and forced convection, calculation of heat transfer coefficient, local and average heat transfer coefficient, simple related problems

- Stefan's Boltzmann law of radiation, black body radiation, gray body radiation, simple related problems
- Evaporation: Horizontal tube evaporator, vertical tube evaporator

5. Thermodynamics (20 hrs)

- Introduction and basic concepts: System, surrounding, homogeneous and heterogeneous systems, closed and open systems, intensive and extensive properties, state and path function. Concept of internal energy, enthalpy, entropy, free energy and equilibrium, Equation of state, ideal gas law, Vander Waal's equation, Zeroth law of thermodynamics
- First law of thermodynamics: calculation of internal energy, enthalpy, heat and work
- Second law of thermodynamics and its applications
- Third law of thermodynamics and its applications

LIST OF PRACTICALS

1. To verify Bernoulli's theorem on hydraulic bench.
2. To observe the pattern of laminar and turbulent flow.
3. To find the rate of filtration using filter press.
4. To carry out the sieve analysis of a product obtained from size reduction equipment such as ball mill, grinder etc.
5. To perform an experiment on cyclone separator.
6. To measure the thermal conductivity of insulating materials.
7. Measurement of emissivity of test surfaces.
8. To prove Stefan- Boltman's Law.
9. To measure diffusivity of solids in liquid or gas.
10. To determine the drying characteristics of a given substance (drying rate measurement) and draw the drying curve.
11. To carry out the calibration of a temperature measuring device on temperature calibration test rig.

INSTRUCTIONAL STRATEGY

The teacher may show the Belt conveyor, Chain conveyor and other machinery and their operations by taking the students to industry or in Lab.

RECOMMENDED BOOKS

1. Unit Operations of Chemical Engineering by Mcabe and Smith,
2. Unit Operations Vol. I & II by Chatterjii, Khanna Publishers,
3. Heat Transfer by D.Q. Kern
4. Mass Transfer Operation by Treybal
5. Chemical Engineering I & II by Coulson & Richardson.
6. Introduction to Chemical Engineering by Badger and Banchero.
7. Introduction to Chemical Engineering Thermodynamics by Smith and Vanness, Mc Graw Hill
8. Engineering Thermodynamics by P.K.Nag

SUGGESTED DISTRIBUTION OF MARKS

Sr. No	Time Allotted (Hrs)	Marks Allotted (%)
1	10	10
2.	15	20
3.	15	20
4.	20	25
5.	20	25
Total	**80**	**100**

3.4 FUELS AND FURNACES

L	T	P
4	-	4

RATIONALE

Ceramic materials are manufactured at high temperature so the knowledge of fuels and furnaces is necessary for proper processing and quality products. Moreover ceramic materials are also used for high temperature applications therefore, for their characterization knowledge of fuels and furnaces are required.

DETAILED CONTENTS

1. Theory of combustion: Actual air required for combustion, theoretical and excess air, simple problems related to combustion. (10 hrs)

2. Types of fuels: Solid, Liquid and Gaseous fuels. (24 hrs)

   Solid Fuels: Coal and Coke, Classification of coal, Properties of coal. Combustible and Non-combustible constituents, Ignition temperature, pulverised coal and its utilisation. Coke as secondary fuel. Its properties and uses. Testing- Proximate analysis, Ultimate analysis, Orsat analysis and determination of calorific value by Bomb Calorimeter.

   Liquid fuels: Indian resources, types, properties of various petroleum products, testing of liquid fuels, octane and cetane number, calorific value, flash point and fire point, viscosity determination, burner for liquid fuels (atomizer, cup & cone burner, squirrel gauge).

   Gaseous fuels: Composition, calorific value and uses of natural gas, producer gas, water gas, LPG. Burners for gaseous fuels.

3. Furnaces and Kilns (30 hrs)

   Furnaces: Classification of furnaces, furnace atmosphere, regenerators and recuperators, description of muffle furnace, tank furnace, blast furnace, electrical furnace and annealing furnace.
   Kilns:- Classification of kilns, description of Downdraft, Shuttle kiln, Pusher kiln, Hoffman’s kiln.

   Furnace and Kiln Accessories: Brief explanation about fire box, chimney, crown, damper and stack. Definition, type and mechanism of draught and dampers.

Pyrometery and Pyroscope: Pyroscope such as seger cones, holdcrafts bar, bullers ring. Pyrometers: Optical, Radiation, Infrared, Resistance and thermocouple pyrometers.

LIST OF PRACTICALS

1. To determine the moisture content of a given fuel.
2. To determine the calorific value of coal by bomb calorimeter.
3. To determine the flash point of a given fuel.
4. Determination of viscosity of oil by Redwood viscometer or Torsion viscometer.
5. To determine the Water absorption by different raw materials (powders).
6. Elementary idea about furnace and kiln design.
7. Thermocouple calibration.
8. Proximate analysis of coal.
9. Determination of grind ability index of coal.

INSTRUTIONAL STRATEGY

The teachers should give emphasis on the basic concepts and principles in the subject.

RECOMMENDED BOOKS

1. Elements of Fuels, Furnaces and Refractories by O.P. Gupta, Khanna Publishers.
2. Industrial Chemistry by Jain and Jain.

SUGGESTED DISTRIBUTION OF MARKS

Sr. No	Time Allotted (Hrs)	Marks Allotted (%)
1	10	15
2.	24	40
3.	30	45
Total	**64**	**100**

3.5 CERAMIC MACHINERIES

L	T	P
4	-	2

RATIONALE

A thorough knowledge of the important machineries used in the ceramic industries enable the students to carry out various processes efficiently; hence this subject is very essential.

DETAILED CONTENTS

1. Size Reduction: Selection of crushing & grinding equipments. Definition of closed and open circuit operations. Classification of size reduction machinery. (12 hrs)

   - Crushers: Introduction, single and double toggle jaw crushers, Gyratory crushers, Crushing rolls and hammer mills, edge runner etc.

   - Grinding: Introduction, pan grinding, ring roll mills, ball mills, pot mills, pebble mill, rod and tube mills, cylindrical ball mill, conical mills, ball tube mills and their parts, quantity of balls, size of balls. Factors effecting grinding efficiency.

2. Size Separation: wet classifiers, Air, Electromagnetic / magnet separators, vibrating sieve, slip lifting & Diaphragm pump, Filter press, Vacuum filter, Centrifugal De-watering. (07 hrs)

3. Mixing and Body Making: De-airing single and double arc plug mills and plugging equipments.Extruders, kneading equipments, weet pan mill, mixers, blunger, agitator etc. (08 hrs)

4. Shaping Machine: Potters wheel, Jigger & Jolly, Batting machine, Semi & fully automatic jiggers, Roller machines, Extrusion wire cutting machines, (07 hrs)

5. Pressing Machines: Important parameters of pressing (Die, Powder & Pressure) Toggle press, Screw press, friction press, Hydraulic press, vibratory compaction machine Isostatic press, Hot isostatic press(HIP),Injection moulding, Tape casting, Tile press and their parts. (10 hrs)

6. Dryers: Unheated Dryers, Heated Dryers, Batch Dryers, Chamber and Corridor dryers. Humidity dryers, Continuous dryears, Dobbins or potters stove, Tunnel dryers. (06 hrs)

7. Material Handling Equipments: Portable power driven machines, permanent installations, flight, belt & screw conveyors, conveying through pipes, slurry pumps, bucket elevator (06 hrs)

8. Testing Equipments: Vicat apparatus, Le- chatlier apparatus, MOR testing machine, Autoclave machine, abrasion testing machine, Infra-red moisture balance. (08 hrs)

LIST OF PRACTICALS

1. To grind a given sample in ball mill.
2. To study the operation of crushers.
3. To study the operation of magnetic separator.
4. To filter the flow of slip through filter press.
5. To study the operation of jiggering and jollying machine.
6. To study the operation of pressing machine.
7. To study the operation of vibrating machine.
8. To study the operation of Blunger machine.
9. To study the operation of Agitator machine.
10. Study of natural and artificial drying.

INSTRUCTIONAL STRATEGY

The teachers should take the students to industry for demonstration of working machinery, relevant to the subject.

RECOMMENDED BOOKS

1. Industrial Ceramic by Singer & Singer, IBH Publisher.
2. A Concise Introduction to Ceramics by George C. Phillips, Amazon Publication
3. Ceramics, Mastering the Craft by Richard Zakin, American Ceramic Society Publication,

SUGGESTED DISTRIBUTION OF MARKS

Sr. No	Time Allotted (Hrs)	Marks Allotted (%)
1	12	18
2.	07	10
3.	08	12
4.	07	10
5.	10	18
6.	06	10
7.	06	10
8.	08	12
Total	**64**	**100**

3.6 COMPUTER APPLICATIONS IN CERAMIC INDUSTRIES

L	T	P
-	-	4

RATIONALE

This subject enables the students to make drawings using computer software, take prints/plots.

DETAILED CONTENTS

1. Introduction to AutoCAD Starting up, practice on – how to create a new drawing file, setting drawing limits and saving a file, drawing lines in different ways using absolute co-ordinates, user co-ordinates, WCS, UCS, drawing lines, circles, arcs, ellipses, polygons, splines, polylines, zoom commands

2. Practice on Edit commands such as erase, copy, mirror, array, offset, rotate, oops, undo, redo, scale, stretch, trim, break, extend, chamfer, fillet

3. Practice on text commands, single line text, paragraph text, editing text, text size, text styles, changing properties commands

4. Practice on layer commands, creating layer, freeze, layer on/off colour assigning, making a layer, current layer, load line type, lock and unlock layer, move from one layer to other.

5. Practice on Hatching-Hatch pattern selection

6. Practice on dimensioning – linear dimensioning, angular dimensioning radius/diameter dimensioning, O-snap command, aligned dimensioning, editing of dimensioning, tolerances in dimensioning

7. Blocks and X-refs - How to make a block, how to insert a block, using block in any drawing, working with x-refs, x-ref options

8. Plot commands. Export/import commands

9. Practice on making part and complete design (like cap, plate, tiles blocks etc.) made by ceramic materials of components by doing exercises

INSTRUCTIONAL STRATEGY

The students must be taught theory along with practical and design the product for better aesthetic look. The students also be taken to the industry where designing of ceramic product and machines are done.

RECOMMENDED BOOKS

1. AutoCad by RW Leigh, Galgotia, N.D.
2. Engineering Drawing with AutoCAD 2000 by T. Jaypooran, Vikas Publishing House