

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2022(COGC-2022) Semester - V

Course Title: Advanced Refractory (Course Code: 4355203)

Diploma programme in which this course is offered	Semester in which offered
Ceramic engineering	5 th semester

1. RATIONALE

Diploma ceramic engineers have to work with the refractory raw material and for this they should know microstructure and properties of refractory materials, chemical and mechanical properties. Advance refractory is a subject that imparts knowledge of properties and application, testing of refractory products. Hence the course has been designed to develop these skills and its associated cognitive, practical and effective domain learning outcomes.

2. COMPETENCY

The course should be taught and curriculum should be implemented with the aim to develop required skills so that students are able to acquire following competency:

- Plan and supervise the use of refractory on the basis of refractory properties.

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with this competency are to be developed in the student to display the following COs:

- a) Describe microstructures of refractories.
- b) Able to use refractory on the basis of its properties in different industries.
- c) Implement knowledge of kiln furniture in production of different ceramic articles.
- d) Perform different types of tests for Refractory.
- e) Implement pollution control and safety measures in refractory industries.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (CI+T/2+P/2)	Examination Scheme				Total Marks
				Theory Marks		Practical Marks		
CI	T	P	C	CA	ESE	CA	ESE	
3	-	4	5	30*	70	25	25	150

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

Legends: *L*-Lecture; *T*- Tutorial/Teacher Guided Theory Practice; *P* -Practical; *C* – Credit, *CA* - Continuous Assessment; *ESE* -End Semester Examination.

5. SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) that are the sub-components of the COs. Some of the PrOs marked '*' are compulsory, as they are crucial for that particular CO. These PrOs need to be attained at least at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Prepare Insulating brick.	I, II, III	6
2	Prepare acid resistance brick.	I, II, III	6
3	Prepare high alumina brick.	I, II, III	6
4	Determine the bulk density of given refractory sample.	IV	6
5	Determination of Modulus of rupture (MOR) of refractories.	IV	4
6	Determine the porosity of a given refractory sample.	IV	6
7	Determine Cold Crushing Strength of given Refractory sample.	IV	4
8	Determine specific gravity of given Refractory sample.	IV	6
9	Determine R.U.L of given Refractory sample.	IV	4
10	Determine P.C.E Value of a given sample.	IV	4
11	Determine thermal shock resistance of a given sample.	IV	4
Minimum Practical Exercises required			56

Note

- i. More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.
- ii. The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency..

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Prepare of experimental setup	20
2	Perform the practical	20
3	Follow safe practices measures	10

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
4	Record observations correctly	20
5	Interpret the result and conclude	30
Total		100

6. MAJOR EQUIPMENT/ INSTRUMENTS AND SOFTWARE REQUIRED

These major equipment/instruments and Software required to develop PrOs are given below with broad specifications to facilitate procurement of them by the administrators/management of the institutes. This will ensure conduction of practical in all institutions across the state in proper way so that the desired skills are developed in students.

S. No.	Equipment Name with Broad Specifications	Pr.No.
1	Sieve shaker with sieve set	1,2,3
2	Digital weight balance	1,2,3,4,6,8
3	Water bath	4,6,8
4	Hot air oven	4,6,8
5	Furnace	1,2,3,9,10
6	Pastel and Mortar	1,2,3
7	UTM	5,7
8	Pressing machine	1,2,3

7. AFFECTIVE DOMAIN OUTCOMES

The following **sample** Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned Cos and PrOs. More could be added to fulfill the development of this competency.

- a) Work as a leader/a team member.
- b) Follow ethical practices.
- c) Practice environmental friendly methods and processes.

The ADOs are best developed through the laboratory/field-based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- i. 'Valuing Level' in 1st year
- ii. 'Organization Level' in 2nd year.
- iii. 'Characterization Level' in 3rd year.

8. UNDERPINNING THEORY

The major Underpinning Theory is formulated as given below and only higher level UOs of *Revised Bloom's taxonomy* are mentioned for development of the COs and competency in the students by the teachers. (Higher level UOs automatically include lower level UOs in them). If required, more such higher level UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application level)	Topics and Sub-topics
Unit – I Micro Structure and its Relation to Properties of Refractory Materials	1a. State thermo-chemical reaction in fire bricks 1b. Explain alumina-silica phase diagrams of different refractory systems.	1.1 Thermo-chemical reaction in fire bricks 1.2 Study of alumina-silica phase diagram refractory system
Unit – II Uses	2a. Identify appropriate Refractory materials for Industries.	2.1 Use of refractory in ferrous industries. 2.2 Use of refractory in non-ferrous industries. 2.3 Use of refractory in boilers. 2.4 Use of refractory in current industries.
Unit – III Kiln furniture	3a. Explain various kiln furniture and their manufacturing method.	3.1 Introduction. 3.2 Details of different kiln furniture like refractory bricks, refractory blocks, muffle, saggars, glass house pots, crucible and ladle refractory.
Unit – IV Properties and Tests of Refractory	4a. Identify different physical and thermal properties of Refractory. 3b. Perform different types of tests for Refractory.	4.1 Physical properties of different types of refractory bricks like porosity, permeability, specific gravity, bulk density etc. 4.2 Determination of fusion point. load bearing capacity, expansion and shrinkage of refractory, thermal conductivity, electrical conductivity, abrasion resistance and spalling resistance.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application level)	Topics and Sub-topics
Unit –V Pollution Control and Safety in Refractory Industries	5a. Explain various reasons for pollution. 5b. Apply precaution.	5.1. Pollution in Refractory industries 5.2. Precaution during manufacturing process of Refractory articles.

Note: The UOs need to be formulated at the 'Application Level' and above of Revised Bloom's Taxonomy' to accelerate the attainment of the COs and the competency.

10. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Micro Structure and its Relation to Properties of Refractory Materials	8	5	5	2	12
II	Uses	8	4	6	6	16
III	Kiln furniture	8	2	5	5	12
IV	Properties and Tests of Refractory	12	2	8	8	18
V	Pollution Control and Safety in Refractory Industries	6	2	5	5	12
Total		42	15	29	26	70

Legends: R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)

Note: This specification table provides general guidelines to assist student for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.

11. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related **co-curricular** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare small reports (of 1 to 5 pages for each activity). For micro project report should be as per suggested format, for other activities students and teachers together can decide the format of the report. Students should also collect/record physical evidences such as photographs/videos of the activities for their (student's) portfolio which will be useful for their placement interviews:

- Prepare list of some Refractory articles.
- Undertake micro-projects in teams
- Give seminar on any relevant topic.
- Undertake a market survey for refractory article.

- e) Prepare showcase portfolios.
- f) Prepare charts containing details of various raw materials.

12. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

- a) Massive open online courses (**MOOCs**) may be used to teach various topics/sub topics.
- b) Guide student(s) in undertaking micro-projects.
- c) **'CI' in section No. 4** means different types of teaching methods that are to be employed by teachers to develop the outcomes.
- d) About **20% of the topics/sub-topics** which are relatively simpler or descriptive in nature is to be given to the students for **self-learning**, but to be assessing during different assessment methods.
- e) With respect to **section No.11**, teachers need to ensure to create opportunities and provisions for **co-curricular activities**.
- f) Guide students on how to address issues on environment and sustainability using the knowledge of this course.
- g) Guide students for using data manuals.

13. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project is group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, the number of students in the group should **not exceed three**.

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total work load on each student due to the micro-project should be about **14 to 16 (Fourteen to sixteen) student engagement hours** (i.e., about one hour per week) during the course. The students ought to submit micro-project by the end of the semester (so that they develop the industry-oriented COs).

A suggestive list of micro-projects is given here. This should relate highly with competency of the course and the COs. Similar micro-projects could be added by the concerned course teacher:

- a) **Refractory industries in India: Identify the different ceramic industries located in different parts of India and prepare the report.**
- b) **Refractory Bricks: Prepare refractory bricks from the available raw materials in local area.**
- c) **Refractory Test: Perform different tests on the prepared refractory.**
- d) **Pollution: Identify different pollutions in ceramic industries.**

14. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication with place, year and ISBN
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S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Elements of Fuels, Furnaces & Refractories	O.P.Gupta	Khanna publications;2016;9788120351578
2	Refractory Technology: Fundamentals and Applications	Ritwik Sarkar	CRC press;2016;1498754252
3	Refractory Materials: Processing, Properties and Applications	Subir Biswas	Ane Books Pvt. Ltd; 2021, 978-9390658725
4	Refractories	F.H.Norton	McGraw-Hill
5	Refractories and its Applications	Kenneth Shaw	Halsted Press Div.,Wiley
6	REFRACTORIES Production And Properties	J H Chesters	W P;2005; 978-1845691202

15. SUGGESTED LEARNING WEBSITES

1. http://en.wikipedia.org/wiki/Category:Refractory_materials
2. <https://en.wikipedia.org/wiki/Refractory>
3. https://www.cumi-murugappa.com/refractories/ind_carbon.html
4. <http://www.firebricks.co.in>
5. <https://www.corrosionpedia.com/2/1426/corrosion-101/refractory-metalsproperties-types-and-applications>
6. <https://www.worldrefractories.org/about-refractories>
7. <https://www.refractorymetal.org/types-of-refractory-materials-applications/>
8. https://en.wikipedia.org/wiki/Blast_furnace

16. PO-COMPETENCY-CO MAPPING

Semester V	CERAMIC MATERIALS (Course Code: 4335204)						
	POs and PSOs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solutions	PO 4 Engineering Tools, Experimentation & Testing	PO 5 Engineering practices for society, sustainability & Environment.	PO 6 Project Management	PO 7 Life-long learning
<u>Competency</u>	<ul style="list-style-type: none"> Plan and supervise the use of refractory on the basis of refractory properties. 						
<u>Course Outcomes</u>							
CO a) Describe microstructures of refractories.	3	1	1	-	-	-	1
CO b) Able to use refractory on the basis of its properties in different industries.	3	1	2	2	1	1	2
CO c) Implement knowledge of kiln furniture in production of different ceramic articles.	3	1	1	1	-	-	2
CO d) Perform different types of tests for Refractory.	3	3	3	3	2	2	2
CO e) Implement pollution control and safety measures in refractory industries.	2	1	1	1	2	1	2

Legend: '3' for high, '2' for medium, '1' for low or '-' for the relevant correlation of each competency, CO, with PO/ PSO

15. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

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