



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Diploma

Branch: Ceramic Technology

Course / Subject Code: DI03052021

Course/Subject Name: Vitreous Enamel

| | |
|-------------------------|-----------------|
| w.e.f. Academic Year: | 2024-25 |
| Semester: | 3 rd |
| Category of the Course: | PCC |

| | |
|----------------------|---|
| Prerequisite: | NA |
| Rationale: | A ceramic engineer needs to utilize vitreous enamel to coat metal surfaces. To achieve this, they should understand the raw materials, how to prepare the metal surface for enameling, perform batch calculations, and apply the enamel through processing techniques. Therefore, the course has been structured to cultivate these skills, along with the related cognitive, practical, and emotional learning outcomes. |

Course Outcome:

After Completion of the Course, Student will able to:

| No | Course Outcomes | RBT Level |
|----|---|-----------|
| 01 | Describe the basic concepts, raw material, classification, properties and uses of enamel. | U |
| 02 | Select suitable cleaning methods of enamel. | A |
| 03 | Calculate batch composition and prepare a batch. | A |
| 04 | Describe the preparation, various coating methods, drying, firing, and defects in enamel. | U |
| 05 | Select suitable tests for Enamel. | A |

*Revised Bloom's Taxonomy (RBT)

Teaching and Examination Scheme:

| Teaching Scheme (in Hours) | | | Total Credits L+T+(PR/2) | Assessment Pattern and Marks | | | | Total Marks |
|----------------------------|---|----|-----------------------------|------------------------------|--------|--------|---------------------|-------------|
| L | T | PR | | C | Theory | | Tutorial/ Practical | |
| | | | ESE (E) | | PA (M) | PA (I) | ESE (V) | |
| 3 | 0 | 2 | 4 | 70 | 30 | 20 | 30 | 150 |



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Course Content:

| Unit No. | Content | No.of Hours | % of Weightage |
|----------|--|-------------|-------------------|
| 1 | INTRODUCTION TO ENAMEL 1.1 Define enameling. 1.2 Choose utility of enamels on metal surface. 1.3 lists out different properties of enamel. 1.4 List out types of enamel. 1.5 Differentiate the various types of enamels. 1.6 Classification of enamel making raw materials. 1.7 Refractory materials, 1.8 Fluxes, Colors, Opacifiers, 1.9 Floating agents, Electrolytes Milling of enamel raw materials. | 10 | 21% (14 Marks) |
| 2 | PREPARATION OF METAL SURFACE FOR ENAMELLING 2.1 Various methods adopted for cleaning metal surfaces such as 2.1.1 annealing. 2.1.2 Scaling. 2.1.3 Chemical pickling. 2.1.4 Electrolytic cleaning. 2.1.5 Neutralization. | 6 | 14% (07Marks) |
| 3 | BATCH COMPOSITION AND CALCULATION 3.1 The chemical composition and empirical formula of enamel. 3.2 Methods of calculation of ground coats and covered coats. 3.3 Methods of application of ground coats and cover coats. 3.4 Frits, Necessity and Process of frit making. | 10 | 21% (14 Marks) |
| 4 | PROCESS FOR ENAMELLING 4.1 preparation of enamel slip, ground coats and cover coats. 4.2 Control of enamel slip. 4.3 Methods of application of enamel slip. 4.4 Dry process coating of enamels and Wet process coating of enamels. 4.5 Drying of enamel coats 4.6 List out and explain the types of furnaces used in enameling. 4.7 The defects during firing of enamel coats and their remedies. 4.8 Suggest methods of handling enamel waste. | 12 | 30% (28 Marks) |



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|--------------|---|-----------|-------------------|
| 5 | PROPERTIES AND TESTS OF ENAMEL 5.1 Thermal properties of enamel 5.2 Thermal expansion and contraction of enamels 5.3 Thermal shock tests 5.4 Thermal conductivity 5.5 Adherence 5.6 Hardness 5.7 Elasticity 5.8 Compressive strength 5.9 Abrasion | 7 | 14% (07 Marks) |
| TOTAL | | 45 | 100 |

Suggested Specification Table with Marks (Theory):

| Unit | Unit Title | Teaching Hours | Distribution of Theory Marks | | | |
|--------------|--|----------------|------------------------------|-----------|-----------|-------------|
| | | | R Level | U Level | A Level | Total Marks |
| I | Introduction to enamel | 10 | 4 | 7 | 3 | 14 |
| II | Preparation of metal surface for enameling | 06 | 3 | 3 | 1 | 07 |
| III | Batch composition and calculation | 10 | 3 | 4 | 7 | 14 |
| IV | process for enameling | 12 | 3 | 21 | 4 | 28 |
| V | properties and tests of enamel | 07 | 3 | 3 | 1 | 07 |
| Total | | 45 | 16 | 38 | 16 | 70 |

| Distribution of Theory Marks (in%) | | | | | |
|------------------------------------|---------|---------|---------|---------|---------|
| R Level | U Level | A Level | N Level | E Level | C Level |
| 23% | 54% | 23% | - | - | - |



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Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create(as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

| Sr. No. | Title of Book | Author | Publication with place, year and ISBN |
|---------|---------------------------|----------------|--|
| 1 | Vitreous Enameling | K.A.Maskall | Pergamon Pr ISBN : 978-0080334288 |
| 2 | The Art of Fine Enameling | Karen L. Cohen | Stackpole Books ISBN : 978-0811737920 |
| 3 | Metalwork and Enameling | Herbert Maryon | Hassell Street Press ISBN: 978-1015218093 |
| 4 | Enamelling on Copper | Pat Johnson | The Crowood Press Ltd ISBN : 978-1785002328 |

(b) Open source software and website:

- https://en.wikipedia.org/wiki/Vitreous_enamel
- <https://www.vea.org.uk/what-is-enamel/>
- <https://www.thecrucible.org/guides/enameling-6/vitreous/>
- https://www.vitrex.co.za/ve_applications.html
- <https://www.wgball.co.uk/vitreous-enamel/>
- <https://www.ajwells.com/services/vitreous-enamel/>



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Suggested Course Practical List:

| S. No. | Practical Outcomes (PrOs) | Unit No. | Approx. Hrs. required |
|--------|---|-------------------------|-----------------------|
| 1 | Identify various Raw materials used in enamel | I | 02 |
| 2 | Clean a given metal surface for enameling | II | 02 |
| 3 | Prepare frit for enamel making. | III | 04 |
| 4 | Prepare ground coat enamel. | IV | 04 |
| 5 | Prepare cover coat enamel. | IV | 04 |
| 6 | Apply and fire enamel on given metal surface. | IV | 04 |
| 7 | Prepare color enamel of given composition. | IV | 04 |
| 8 | Apply and fire color enamels on given ware. | IV | 04 |
| 9 | Identify various defects occur in enameled wares with their remedies. | IV | 02 |
| 10 | Identify various properties and tests of enameled wares. | I&V | 02 |
| 11 | Prepare a metal surface for enamel coating | IV | 02 |
| 12 | Apply enamel paint on metal surface. | IV | 02 |
| 13 | Prepare enamel jewelry articles. | IV | 02 |
| 14 | Visit frit industry and prepare report of all process | III | 06 |
| | Total | Minimum Required | 30Hrs |

List of Laboratory/Learning Resources Required:

| S. No. | Equipment Name with Broad Specifications | PrO.No. |
|--------|--|--------------|
| 1 | Sieve shaker with sieve set | 1,3,4,5,7 |
| 2 | Digital weight balance | 1,3,4,5,7, |
| 3 | Pot mill | 4,5,7 |
| 4 | Hot air oven | 1,3,4,5,7,12 |
| 5 | Spray gun | 6,8 |
| 6 | Muffle furnace | 1,3,4,5,7,11 |



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Suggested Project List:

A suggested list of projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

PROJECT 1: Enamel painting or art – Enamel paint on metal or other surfaces.

PROJECT 2: Decorative ware: collect different types of enamel product.

PROJECT 3: Application: Prepare a report of different application of enamel.

Suggested Activities for Students:

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 perform following activities in group and prepare reports of about 5 pages for each activity. They should also collect/record physical evidences for their (student's) portfolio which may be useful for their placement interviews:

- a) Under take micro-projects in team/individually.
- b) Encourage Students for creating and designing water treatment processes using waste materials.
- c) Students are encouraged to register themselves in various **MOOCs** such as: **Swayam, edx, Coursera, Udemy** etc to further enhance their learning.



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