GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Branch: Metallurgy
Subject Code : BE05021041
Subject Name: Advanced Ferrous Metal Production

w. e. f. Academic Year:	2024-25
Semester:	5
Category of the Course:	Professional Elective Course - 1

Prerequisite:	Ferrous Metal Production
Rationale:	The course on Advanced Ferrous Metal Production is designed to build upon the fundamental knowledge of conventional iron and steelmaking and introduce students to modern developments in the ferrous industry. With increasing demand for high-quality steels, energy efficiency, and environmentally sustainable production, it is essential for engineers to understand advanced operational practices and emerging technologies. This course focuses on process optimization, clean steelmaking, and enhanced productivity in blast furnace, BOF, and EAF routes. It also addresses alternative ironmaking processes, including low-carbon and hydrogen-based technologies, aligned with global decarbonization goals. Emphasis is given to secondary refining, inclusion control, and advanced continuous casting for superior product quality. The course introduces automation, sensors, and digitalization concepts used in modern smart steel plants. Energy management, waste utilization, and environmental impact reduction are also discussed to promote sustainable metallurgy. Through case studies and practical exercises, students gain exposure to real industrial challenges and solutions. The aim is to prepare graduates to meet the technological, quality, and sustainability demands of the contemporary steel industry.

Course Outcome:

After Completion of the Course, Student should be able to:

Sr. No.	CO statement	Marks % weightage
CO-1	Analyze advanced ironmaking and steelmaking processes with respect to productivity, process efficiency, and emerging low-carbon technologies.	45
CO-2	Evaluate the influence of secondary refining, inclusion control, and continuous casting parameters on steel quality and performance.	45
CO-3	Apply modern concepts of process optimization, automation, and sustainability to improve operational efficiency in ferrous metal production.	10

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	PBL*	Total no of hours per semester		ESE (E)	PA / CA (M)	PA/ CA (I)	PBL* (I)	ESE (V)	
45	0	30	15	90	03	70	30	20	30	50	200

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, ESE = End Semester Examination, PA = Progressive Assessment
*** Problem Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual.**

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1	**Raw Material Engineering & Burden Optimization** Iron ore beneficiation trends for low-grade ores, Pellet & reducibility control, Sinters and its effect on BF permeability, burden distribution Bell-less top concept , Coke quality indices.	04	09
2	**Advanced Blast Furnace Operation**: Pulverized Coal Injection (PCI) optimization, Tuyere raceway phenomena, BF productivity enhancement techniques, Hearth wear, refractory life management, Process disturbances & troubleshooting (scaffolding, slipping, channeling).	06	13
3	**Emerging Ironmaking Routes:** Gas-based DRI vs Coal-based DRI comparison (Indian relevance), Hydrogen-based ironmaking (H_2-DRI concept) , COREX / FINEX process philosophy. Smelting reduction vs Blast Furnace economics, Carbon footprint comparison of routes.	08	18
4	**Advanced BOF & EAF Steelmaking Practices:** Dynamic BOF control using off-gas analysis, Slag splashing for converter lining life, Foamy slag practice in EAF, Energy optimization in EAF (UHP furnaces), Scrap preheating technologies, Yield improvement techniques.	08	18
5	**Clean Steel Technology & Inclusion Engineering:** Inclusion morphology control (Calcium treatment science), Steel cleanliness measurement (O, N, H control), Argon stirring optimization, Reoxidation prevention practices, Tundish metallurgy as refining reactor, Production of special steels (API, Automotive grades)	06	13
6	**Advanced Continuous Casting & Solidification Control:** Mold heat transfer & oscillation marks, EMS (Electromagnetic Stirring) concept, CC defects: breakout, segregation, cracks, Near-net shape casting (Thin slab / strip casting introduction)	06	13
7	**Process Automation, Sensors & Digital Steelmaking**:	03	07

	Smart sensors in steel plants (laser, thermal imaging), Data-driven process control, Basics of Industry 4.0 in steelmaking		
8	**Energy, Environment & Sustainable Steel Production**: Waste heat recovery in BF/BOF/EAF, Slag utilization & circular economy, and CO_2 reduction strategies in steel plants.	**04**	**09**
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
15	**15**	**20**	**30**	**20**	**0**

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

The syllabus of Advanced Ferrous Metal Productions directly contributes to:

SDG 4	Quality Education
SDG 7	Affordable and Clean Energy
SDG 9	Industry, Innovation and Infrastructure
SDG 12	Responsible Consumption and Production

Reference Books:

1. Ironmaking and steelmaking: Theory and Practice, Ghosh Ahindra, Chatterjee Amit, PhiLearning Private Limited, (2001)
2. An introduction to modern steel making, R. H. Tupkary, Khanna Publishers (2000)
3. An introduction to modern iron making, R. H. Tupkary, Khanna Publishers (2004)
4. The Making, Shaping and Treating of Steel. Fruehan, R.J.. 11th Edition, The AISE Steel Foundation, Pittsburgh.

List of Experiments:

1. BOF heat balance with scrap % optimization Excel based calculated sheet.
2. Inclusion Rating measurement using ASTM E45 and modification case study (Al → Ca treatment).
3. Process flow chart preparation BF-BOF vs DRI-EAF route.
4. Continuous casting defect analysis using real photographs.
5. To Prepare Pallets on the disk palletizer machine & measure the shatter index for pellets.
6. Study and Comparison of Hydrogen-Based Steelmaking and Conventional Steelmaking Routes.
7. Study on Scrap Charging Practices in Electric Arc Furnace Steelmaking.

8. Case study on Recycling and Reuse of Slag in Steel Industry.
9. Seminar presentation and Report Submission of a given topic based on Recent developments in Steel Making Technology.
10. Comparative study on LF, VD, VOD, and RH degassing methods.
11. Poster on Industry 4.0 in steelmaking.
12. To write a report on Industrial visit / Expert Talk.

Major Equipment:

-Shatter Index Test set up.

-Disk Palletizing machine.

-Metallurgical Microscope

List of Open Source Software/learning website:

1. https://nptel.ac.in/courses/113104059/
2. www.ocw.mit.edu

List of suggested activities for Problem-based Learning (PBL):

Sr. No.	PBL Category	Name of the activity	No. of hours	Evaluation Criteria
1	Industry / Research Laboratory Visit	Industry / Research laboratory Visit	Visit = 5hrs, Report preparation = 5hrs Total = 10hrs	Based on report submitted. Report should contain observations and calculations based on industry/ lab data.
2	Video Based Learning	Technical Video based learning related to the subject (MOOC/ NPTEL Video)	Duration of video = 5hrs Report preparation = 5hrs Total = 10hrs	Report /presentation based on the video learning outcomes.
		Self-learning on-line course	Minimum duration of the course should be 10hrs.	Examination based assessment at the end of course. Based on the certificate produced.
		Annotated Video Explanation of Concept/Problem	10hrs (Preparation + Recording + Submission)	Based on accuracy of explanation, clarity, and presentation style.

3	Assignment/ Technical Writing / Research Writing	Assignment writing. Numerical based assignment is preferable.	5 assignments of 2hrs each. Total = 10hrs	Based on the assignment submitted.
		Blog or Technical Article Writing	10hrs (Research – 6hrs, Writing – 4hrs)	Based on originality, technical content, references cited, and clarity of communication.
4	Complex Problem-Solving targeting relevant SDGs. / Mini Project	Complex problem solving	Maximum 2 problem. Study of the problem and solution finding, Total = 15 hrs	Based on the depth of the solution submitted.
5	Research Paper Review / Analysis	Discussion on research paper based on relevant subject (Indexed Journal)	5 research paper = 20 hrs	Summarize research paper and evaluate critical parameters
6	Poster/ Chart/ Power point presentation	Poster/chart/power point preparation on technical topics	Duration = 6 hrs	Based on poster/chart preparation and presentation skills
7	Micro Project	Working/non-working model on technical topics	Working = 10 hrs Non-working = 10 hrs	Based on inter department/external evaluation
8	Group Discussion / Quiz / Simulation	Group Discussion on emerging/trending technical topics based on subject	Duration = 1 hrs each	Based on performance in group discussion, technical depth, knowledge etc.
		Online Technical Quizzes/ MCQ test/ Simulations	Multiple quizzes summing up to 10hrs	Based on quiz score and reflection summary.
9	Case Study Analysis / Seminar	Real world case studies-based learning	Duration of data collection/study = 5hrs Report preparation = 5hrs Total = 10hrs	Based on in-depth study, technical depth, data collected, fact finding, etc.
10	Other	Patent Search and Innovation Gap Identification	10hrs (Search + Report)	Based on number of relevant patents analyzed and identification of innovation scope.

Note:

1. In alignment with Outcome-Based Education (OBE) and NBA accreditation requirements, the subject Advanced Ferrous Metal Production incorporates.

- Mini Project – 10 Marks
- Micro Project and – 5 Marks
- Seminar activities -– 10 Marks

These activities are incorporated as integral Project-Based Learning (PBL) components. These activities are designed to foster experiential learning, encourage innovation, and strengthen problem-solving skills by engaging students in practical applications of power converter design, simulation, and analysis. The inclusion of PBL ensures that learners develop higher-order cognitive abilities mapped to Bloom's taxonomy, while simultaneously enhancing teamwork, communication, and research competencies essential for professional engineering practice.

2. The hours allocated to specific activities should be proportionate to the total no. of PBL hours and marks.

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