GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021(COGC-2021) Semester - V
Course Title: Alloy Steel
(Code: 4362101)

Diploma Programme in which this course is offered	Semester in which offered
Metallurgy Engineering	6th Semester

1 RATIONALE

The incorporation of the alloy steel subject within the curriculum is geared towards furnishing Metallurgical Engineers with comprehensive knowledge concerning the intricacies of composition, microstructure, properties, and applications associated with a diverse array of steels used on a global scale for specific purposes. Given the extensive variety of steel types utilized in the manufacturing of a wide range of products, it is imperative for a diploma metallurgical engineer to delve into the fundamental aspects, including properties, composition, and applications of these steels. The design of this course is meticulously tailored to provide students with a thorough and foundational understanding of the complexities inherent in Alloy Steels.

2 COMPETENCY

The course content should be taught and curriculum should be implemented with the aim to develop required skills in students so that they are able to acquire following competencies.

- **Select the appropriate alloy steels for intended application.**

3 COURSE OUTCOMES (COs)

At the end of the study of this course the student will be able to:

- CO1: Understand the effects of various alloying elements on properties of steels.
- CO2: Select the appropriate alloy steel for specific application.
- CO3: Discuss the composition, properties and applications of the alloy steels.

4 TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	0	2	4	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

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Observe the microstructure of low carbon steels and identify the phases present in it.	1	3
2	Observe the microstructure of medium carbon steels and identify the phases present in it.	1	3
3	Observe the microstructure of high carbon steels and identify the phases present in it.	1	3
4	To decode the various code/designation system of steels.	2	2
5	To study the effects of alloying elements added to steels.	2	2
6	Identify the various stainless steel based on their microstructure.	3	3
7	Analyze the microstructure of various tool steels.	4	3
8	To do the microstructural case study of EN 31 steel.	5	3
9	Investigate the microstructure of HSLA steels.	5	3
10	Visit the relevant alloy steel industry and write down the report.	5	3
	Total Hours		**28**

Notes:

1. 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.

2. 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.

Sr. No.	Sample Performance Indicators for the PrOs.	Weightage in %
1	Identification of the component and Preparation of experimental Set-up	20
2	Operate equipment set-up	10
3	Observation and recording of the data correctly	10
4	Interpretation of the result and conclusion	20
5	Safety precaution and safety gadgets used	20
6	Submission of report within time limit and attendance in the laboratory	20

6 MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

These major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to user in uniformity of practical in all institutions across the state.

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1	**Metallurgical Microscope:** Magnification: Typically ranges from 50x to 1000x or more. It includes both the objective lens and the eyepiece magnifications. Objective Lenses: Multiple objective lenses with varying magnifications, such as 5x, 10x, 20x, 50x, and 100x. Illumination: Light passes through the specimen from below, useful for transparent or thin sections. Reflected Illumination: Light reflects off the surface of opaque specimens, providing detailed surface examination. Halogen or LED Lighting: Common light sources for better control and longevity. Stage: Allows precise movement of the specimen for easy navigation and examination. Stage Size: Large enough to accommodate various sample sizes. Optical System: Binocular or Trinocular Head: Binocular for visual observation, trinocular for attaching a camera or imaging system. Diopter Adjustment: Individual eye focusing for user comfort. Camera Compatibility: Trinocular microscopes often have a camera port for attaching a camera for image capture and documentation. Focusing System: Coarse and Fine Focusing Knobs: For rapid and precise focusing. Eyepieces: Widefield Eyepieces: Commonly 10x magnification. Objectives: Plan Achromatic Objectives: Corrected for flat field imaging. Contrast Methods: Brightfield, Darkfield, Polarized Light: Various contrast methods for different material examinations. Build and Construction: Sturdy Construction: Designed to withstand continuous usage in industrial or laboratory settings. Anti-Vibration Features: To minimize external vibrations for accurate observations.	**1, 2, 3, 5, 6, 7, 8, 9**

2	**Image Analyzing System:** 1). Grain size Steel Grain size ASTM 1382, E 930 ISO 643, DIN EN 180 643-2003 Prior Austenite Grain Size, ASTM E 112, E 1382 Non ferrous metals and Alloy grain size with above method 2). Non metallic inclusion (Nodules & Flakes) Determination of inclusion types (Oxides, Sulphides, and Oxides-Sulphides) Estander of inclusion ASTM E 1245, E 45 E 1122, ISO 4967, DIN 50602 3).Phase Analysis Relative content of Ferrite/Pearlite Ferrite content in Austenite steel bar. Carbide inhomogenuity in alloyed tool steels. Length of Marstenstitic lenghts & needles. 4).Graphite in ferrous methods ASTM A 247 5).Vectors and knob hardness methods ASTM E 384, E 92 6).Decarbised layer depth ASTM A 247, ISO 3887	**1, 2, 3, 5, 6, 7, 8, 9**

7 AFFECTIVE DOMAIN OUTCOMES

The following sample Affective Domain Outcomes (ADOs) are embedded in many of the abovementioned Cos. More could be added to fulfill the development of this course competency

- Aware about the effect of various alloying elements on properties of steels.
- Participate in class discussion on various engineering applications and suggest the suitable alloy steels suitable for this application.
- Work as independently individuals, displays teamwork, displays leadership quality and professional commitment to ethical practice on daily basis.

8 UNDERPINNING THEORY

The major underpinning theory is given below based on the higher level UOs of Revised Bloom's taxonomy that are formulated for development of the COs and competency. If required, more such UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Major Learning Outcomes	Topics and Sub-topics
UNIT-I Introduction to Steels	1a. Introduction to steels 1b. Classification of steels 1c. Effect of carbon on properties of steels 1d. Effect of inherent impurities on properties of steels 1e. Plain carbon steels, their properties	1.1. Definition of steel 1.2. Classification of steel on the basis of amount of carbon, amount of allying elements, deoxidation, grain coarsening, method of manufacturing, depth of hardening and form and uses.

	and applications	1.3. Effects of carbon on properties of steels. 1.4. Effects of sulphur and phosphorous on properties of steels. 1.5. Composition, properties and applications of low carbon steel, mild Steel, medium carbon steel and high carbon steel.
UNIT-II Introduction to Alloy Steels	2a. Needs of alloy steels. 2b. Properties and uses of alloying elements. 2c. Designation of steels as per various code and standards.	2.1. Limitations of plain carbon steels. 2.2. Justify the needs of alloy steels. 2.3. Properties and uses of alloying elements like silicon, manganese, nickle, chromium, tungsten, molybdenum, vanadium, titanium, cobalt, aluminium and boron. 2.4. Designation of steels as per IS, AISI/SAE, ASTM, EN, DIN.
UNIT-III Stainless Steels	3a. Introduction of stainless steels 3b. Classification of stainless steels 3c. Composition, properties and applications of various stainless steels 3d. Sensitization	3.1. Introduction and definition of stainless steel. 3.2. List of ferrite and austenite stabilizing elements. 3.3. Classification of stainless steels. 3.4. Grades, composition, properties and applications of ferritic stainless steels, austenitic stainless steels, martensitic stainless steels, duplex and precipitation hardened stainless steels. 3.5. Sensitization behavior in austenitic stainless steels.
UNIT-IV Tool Steels	4a. Introduction of tool steels 4b. Needs of tool steels 4c. Classification of tool steels 4d. Composition, properties and applications of various tool steels 4e. Heat treatment of high speed tool steel	4.1. Introduction and definition of tool steels. 4.2. Properties required and uses of tool steels 4.3. Classification of tool steels 4.4. Composition, properties and applications of cold work tool steels, hot work tool steels, high speed tool steels and special purpose tool steels. 4.5. Heat treatment cycle of high speed too steel

UNIT-V Special Purpose Steels	5a. Describe various specia purpose steels like Ausforming steel, Maraging steel, spring steel, ball bearing steel, Hadfield Mn Steel, Dual Phase steels, High strength low alloy steel (HSLA), High temperature alloys, Alloys for heating elements etc.	5.1. Introduction, manufacturing, composition, properties and applications of Ausforming steel, Maraging steel, spring steel, ball bearing steel, Hadfield Mn Steel, Dual Phase steels, High strength low alloy steel (HSLA), Steel for high temperature application, Alloys for heating elements etc.

9 SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction to Steels	08	4	4	2	10
II	Introduction to Alloys Steels	06	4	2	4	10
III	Stainless Steels	12	6	8	6	20
IV	Tool Steels	06	4	4	2	10
V	Special purpose Steels	10	6	8	6	20
	Total	42	24	26	20	70

Legends: R = Remember; U = Understand; A = Apply and above levels (Bloom's revised taxonomy)

Notes:

1. This specification table shall be treated as a general guideline for students and Teachers. The actual distribution of marks in the question paper may slightly vary from above Table.
2. Ask the questions from each topic as per marks weightage. Numerical questions are to be asked only if it is specified. Optional questions must be asked from the same topic.

10 SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related cocurricular activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group

1. Organize field trip to companies or research facilities involved in alloy steel.
2. Analyze the microstructure of various alloy steels and stainless steels.
3. Compare properties and applications of different alloy steels.
4. Assign case studies that explore the application of alloy steels in industry.

11 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) 'L' 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 assessed using different assessment methods.
e) With respect to section No.10, 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.
g) Encourage students to read codes and standards.

12 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 are group-based. However, in the fifth and sixth semesters, it should be preferably be individually undertaken to build up the skill and confidence in every student to become problem solver so that he/she contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should not exceed three.

The micro-project could be industry application based, internet-based, workshop-based, laboratorybased 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 duration of the micro-project should not be less than 16 (sixteen) student engagement hours during the course. The student ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

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

1. List the limitation of plain carbon steel.
2. Prepare reports of need of alloy steel for various industrial applications.
3. Prepare chart of various alloying elements and effects of their addition on properties of steel.
4. Collect samples of tools, check their chemical composition and observe their microstructure.
5. Collect samples of stainless steels, check their chemical composition and observe their microstructure.

13 SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	Introduction to physical metallurgy	Sidney H. Avner	Publisher: McGraw-Hill Inc. ISBN: 9780070850187
2	Physical metallurgy	Vijendra Singh	Publisher: Standard Publishers Distributors ISBN: 978-8186308639
3	Material science and Metallurgy	V.D. Kodgire	Publisher: Everest Publishing House ISBN: 978-8176314008
4	Physical Metallurgy for Engineers	D. S. Clark and W. R. Varney	Publisher: CBS Publishers & Distributors ISBN: 9788123911786
5	Engineering Metallurgy : Applied Physical Metallurgy	R. A. Higgins	Publisher: Butterworth-Heinemann Ltd ISBN: 978-0340568309

14 SOFTWARE/LEARNING WEBSITES

- **https://onlinecourses.nptel.ac.in/noc20_mm07/preview**

- **https://en.wikipedia.org/wiki/SAE_steel_grades**

15 PO-COMPETENCY-CO MAPPING

Semester VI	Alloy Steel (Course Code: 4362101)						
	POs						
Competency & Course Outcomes	**PO 1 Basic knowledgs of**	**& Proble tation**	**Design/ Engineerin & sustainability**	**Engineering Tools, practices for environment**	**Project Managelong e solution**	**Life specific Testing & s**	**Disciplinm Analysi-ment**	**developg Experimensociety, -ment learnin g**
Competency	Select the appropriate alloy steels for intended application						
CO1: Understand the effects of various alloying elements on properties of steels.	3	1	1	0	0	0	1
CO2: Select the appropriate alloy steel for specific application.	3	3	2	1	2	0	3
CO3: Discuss the composition, properties and applications of the alloy steels.	3	2	1	0	1	0	2

16 COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

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