

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)

Semester-V

Course Title: Advance Heat Treatment

(Course Code: 4352105)

Diploma Programme in which this course is offered	Semester in which offered
Metallurgy Engineering	5 th Semester

1. RATIONALE

This course builds upon the foundational knowledge gained from the "Heat Treatment" course. It expands upon the principles and techniques covered in the previous course to provide a more comprehensive understanding of heat treatment for commercially available ferrous alloys. With an emphasis on both theoretical concepts and practical applications, this course delves deeper into the heat treatment processes of different grades of ferrous alloys, including the incorporation of advanced techniques. By taking this course after studying the "Heat Treatment" course, students will further enhance their expertise in understanding and implementing heat treatment cycles specifically tailored for commercially used ferrous alloys.

2. COMPETENCY

The course content should be taught and implemented with the aim to develop different types of skills so that students are able to acquire the following competency:

- **Suggest heat treatment cycles for specific alloys based on service requirements.**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with the identified competency are to be developed in the student for the achievement of the following COs:

1. Select appropriate heat treatment furnace according to specific applications.
2. Suggest an optimal heat treatment cycle for commercial steel to attain the desired properties.
3. Recommend suitable heat treatment cycle for cast iron to achieve the desired properties.
4. Select special heat treatment technique for steel based on applications.

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	
2	0	2	3	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) 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.'

Sr. No.	EXERCISES/ PRACTICAL	Unit No.	Approx. Hrs. Required
1.	Identify the different components of heat treatment furnaces and elaborate on their respective functions.	I	04
2.	Perform suitable heat treatment on Manganese steel specimen and study its effect on microstructure and hardness.	II	04
3.	Perform suitable heat treatment on Chromium steel specimen and study its effect on microstructure and hardness.	II	04
4.	Perform suitable heat treatment on Stainless steel specimen and study its effect on microstructure and hardness.	II	04
5.	Perform suitable heat treatment on Grey Cast Iron specimen and study its effect on microstructure and hardness.	III	04
6.	Perform suitable heat treatment on Nodular Cast Iron specimen and study its effect on microstructure and hardness.	III	04
7.	Perform special heat treatment on alloy steel and study its effect on microstructure and hardness.	IV	04
Total hours			28 Hrs.

Notes:

- 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.
- 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 raw material	20
2	Operate equipment and set-up carefully	10
3	Safety precaution and safety gadgets used	10
4	Observation and recording of results	20
5	Interpretation of the result and conclusion	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's in all institutions across the state.

Sr. No.	Equipment Name with Broad Specifications	PrOs. No.
1.	Muffle furnace Maximum Operating Temperatures: 1200 °C Heating element: Kanthal wire microprocessor based PID temperature controller	1 to 7
2.	Metallography Specimen preparation set up	1 to 7
3.	Double Disc Polishing Machine, Electrolytic polishing and etching machine	1 to 7
4.	Metallurgical Microscope Magnification: 1000 X	1 to 7
5.	Image Analyzer	1 to 7
6.	Rockwell/Brinell/Digital Portable Hardness Testing Machine	1 to 7

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 fulfil the development of this competency.

- Correlate the conventional heat treatment processes with advance heat treatment processes.
- Discuss the practical limitation of advance heat treatment processes.
- List down the process variable of the heat treatment process.
- Participates in class discussion related to heat treatment operations.
- Work as independently individuals, displays teamwork, displays leadership quality and professional commitment to ethical practice on daily basis.
- Practice environment friendly methods and processes.
- Be aware about the safety aspects during the heat treatment process.

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:

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

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 Heat Treatment Furnaces	1.a Classify heat treatment furnaces. 1.b Discuss working principle of heat treatment furnaces.	1.1 Introduction to Furnaces 1.2 Classification of Different type of Heat treatment furnaces 1.3 Explain working Principle of various Heat treatment furnaces
Unit – II Heat Treatment of Commercial Steel	2.a Explain heat treatment processes of different types of steels. 2.b Examine changes occurs in mechanical properties and microstructure of plain carbon steel, alloy steel and stainless steel after heat treatment.	2.1 Learn Heat treatment process of <ul style="list-style-type: none"> a. Low Carbon steel b. Medium Carbon Steel c. High Carbon Steel d. Manganese steel e. Silicon steel f. Chromium steel g. Nickel-chromium-Molybdenum Steel h. High speed tool steel i. Austenitic stainless steel j. Ferritic stainless Steel k. Martensitic stainless steel
Unit – III Heat Treatment of Cast Iron	3.a Discuss heat treatment processes of different types of cast iron. 3.b Explore the modifications observed in the mechanical properties and microstructure of cast iron after undergoing heat treatment.	3.1 Study heat treatment process of <ul style="list-style-type: none"> a. White cast iron b. Grey cast iron c. Nodular cast iron d. Malleable cast iron
Unit – IV Special Heat Treatment Techniques	4.a Describe special heat treatment techniques. 4.b Analyze effect of special heat treatment on properties of various products.	4.1 Explain special heat treatment techniques like <ul style="list-style-type: none"> a. Austempering b. Martempering c. Subzero treatment d. Patenting e. Ausforming

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction to Heat Treatment Furnaces	04	04	06	02	12
II	Heat Treatment of Commercial Steel	12	08	12	06	26
III	Heat Treatment of Cast Iron	06	04	08	06	18
IV	Special Heat Treatment Techniques	06	04	06	04	14
	Total	28	20	32	18	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 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

1. Visit nearby industries engaged in Heat Treatment (if any) and study the processes are being used.
2. Make a chart for showing heat treatment cycle for different grade of steel.
3. Collect various samples in heat treated conditions and examine their microstructure.
4. Group discussion on pros and cons of different Heat treatment Process.
5. Group discussion on environmental issues and control in the industrial heat treatment.

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) 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 using the knowledge of this course.
- 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 is 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 s/he contributes to the projects of the industry. In special situations where groups must 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, 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 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. Study the effect of heat treatment on microstructure and mechanical properties of Silicon steel.
- 2. Study the effect of heat treatment on microstructure and mechanical properties of Ni-Cr-Mo steel.
- 3. Study the effect of heat treatment on microstructure and mechanical properties of High-Speed Tool steel.
- 4. Study the effect of patenting on microstructure and mechanical properties of alloy steel.
- 5. Compare special heat treatment processes.
- 6. Compare mechanical properties of Heat Treated and As Cast steel sample.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author / Editor	Publication with place, year, and ISBN
1.	Heat Treatment: Principles and Techniques	T. V. Rajan, C. P. Sharma, Ashok Sharma	Prentice-Hall of India Pvt. Ltd., New Delhi, 2007, ISBN 978-8120307162
2.	Heat Treatment of Metals	Vijendra Singh	Standard Publishers Distributors, New Delhi, 2020, ISBN 978-8180140389
3.	Heat Treatment of Metals	B. Zakharov	CBS Publishers, New Delhi, 1998, ISBN 978-8123906010
4.	Heat Treatment of Metals Volume 1	J. L. Smith, G. M. Russel, S. C. Bhatia	CBS Publishers, New Delhi, 2008, ISBN 978-8123916446
5.	Introduction to Physical Metallurgy	Sidney H. Avner	Mc-Graw Hill Education, 2017, ISBN 978-0074630068
6.	Heat Treatment, Selection, and Application of Tool Steels	William E. Bryson	Hanser Publications; 2nd Revised ed. Edition, 2009, ISBN 978-1569903766
7.	Handbook of Heat Treatment of Steels	K. H. Prabhudev	Tata McGraw-Hill Publishing Ltd. New Delhi, 2003, ISBN 978-0074518311

14. SOFTWARE/LEARNING WEBSITES

- 1 <https://nptel.ac.in/courses/113104074>
- 2 <https://nptel.ac.in/courses/112104219>
- 3 <https://msvs-dei.vlabs.ac.in/Quenching.php>
- 4 <https://www.sm-furnaces.com/blog/4-types-of-heat-treating/>
- 5 <https://www.youtube.com/watch?v=6jQ4y0LK1kY>
- 6 <https://fractory.com/heat-treatment-methods/>
- 7 <https://www.iqsdirectory.com/articles/heat-treating.html>

15. PO-COMPETENCY-CO MAPPING

Semester V		Advance Heat Treatment [Course Code: 4352105]						
		POs						
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
Competency		Suggest heat treatment cycles for specific alloys based on service requirements.						
Course Outcomes								
CO1:	Select appropriate heat treatment furnace according to specific applications.	3	-	1	-	2	-	2
CO2:	Suggest an optimal heat treatment cycle for commercial steel to attain the desired properties.	3	2	3	2	1	3	2
CO3:	Recommend suitable heat treatment cycle for cast iron to achieve the desired properties.	3	2	3	2	1	3	2
CO4:	Select special heat treatment technique for steel based on applications.	3	1	3	1	1	3	2

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

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons:

Sr. No.	Name and Designation	Institute	Email
1	Ms. Sonam M. Patel, Lecturer Metallurgy Engineering	Dr. S. & S. S. Ghandhy College of Engineering & Technology, Surat	sonampatel22@gmail.com
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