



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Diploma Engineering

Level: Diploma

Branch: Metallurgy Engineering

Subject Code : DI04021021

Subject Name: Heat Treatment

w. e. f. Academic Year:	2025-26
Semester:	4 th
Category of the Course:	PCC

Prerequisite:	Basic knowledge of physical metallurgy.
Rationale:	Heat treatment is an essential process in metallurgy that modifies the mechanical and physical properties of metals and alloys to achieve desired performance in engineering applications. Industrial sectors such as automotive, aerospace, mining, oil & gas, and manufacturing rely heavily on heat-treated materials for strength, hardness, and toughness. Understanding the principles of phase transformation and control of microstructure through various heat treatment processes enables diploma engineers to supervise, optimize, and ensure the quality of treated components. This subject builds a strong foundation for applying metallurgical principles in industrial heat treatment practices.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
01	Select appropriate heat treatment process to obtain desired mechanical properties.	A
02	Interpret T.T.T. and C.C.T. diagrams of various steels.	A
03	Select suitable surface hardening processes based on applications.	A
04	Examine quality control parameters and common defects in heat-treated products.	U

**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		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 Heat Treatment Processes 1.1 Importance of heat treatment 1.2 Steps involved in heat treatment 1.3 Classification of heat treatment processes	03	10
2.	Phase Transformations 2.1 Limitations of Fe-Fe ₃ C diagram 2.2 Construction of Time Temperature Transformation diagram 2.3 T.T.T. diagram of hypo eutectoid steel, eutectoid steel, hyper eutectoid steel 2.4 Bainitic transformation, Martensitic transformation 2.5 Factors affecting T.T.T. diagram and its limitations 2.6 Applications of T.T.T. diagram 2.7 Effect of alloying elements on T.T.T. diagram 2.8 C.C.T. diagram	10	20
3.	Annealing & Normalizing 3.1 Principle and objectives of annealing 3.2 Various annealing processes used for steels 3.3 Principle and objectives of normalizing 3.4 Difference between annealing and normalizing	10	25
4.	Hardening & Tempering 4.1 Principle and objectives of Hardening Process 4.2 Heat removal Mechanism during Quenching 4.3 Characteristics of quenchants and quenching media 4.4 Hardenability and Jominy End Quench Test 4.5 Need of Tempering process 4.6 Three stage Tempering process 4.7 Precipitation Hardening	10	20
5	Surface Hardening Processes 5.1 Need of Surface hardening processes 5.2 Carburizing Process 5.3 Nitriding Process 5.4 Cyaniding Process 5.5 Induction Hardening Process 5.6 Flame hardening Process	09	15
6	Quality Control in Heat Treatment	03	10



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6.1 Common defects in heat-treated products		
6.2 Factors affecting quality		
6.3 Remedies and preventive measures		
Total	45	100

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	U Level	A Level	N Level	E Level	C Level
25	40	35	0	0	0

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	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
8	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
9	Heat Treatment of Metals	Vijendra Singh	Standard Publishers Distributors, New Delhi, 2020, ISBN 978-8180140389



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(b) Open-source software and website:

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>

Suggested Course Practical List:

No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Interpret T.T.T. diagram of eutectoid steel, hypo eutectoid steel and hyper eutectoid steel.	II	2
2	Perform annealing heat treatment on steel specimen and study its effect on microstructure and hardness of steel.	III	4
3	Perform normalizing heat treatment on steel specimen and study its effect on microstructure and hardness of steel.	III	4
4	Perform hardening heat treatment on steel specimen and study its effect on microstructure and hardness of steel.	IV	4
5	Perform tempering heat treatment on steel specimen and study its effect on microstructure and hardness of steel.	IV	4
6	Determine Hardenability of steel by Jominy End Quench Test.	IV	4
7	Perform carburizing on carbon steel and analyze its effect on hardness.	V	2
8	Perform induction hardening on carbon steel and analyze its effect on hardness.	V	2
9	Analyze effect of nitriding, cyaniding and flame hardening process during industrial visit.	V	2
10	Identify defects occurs in Heat treated products.	VI	2
Total			30



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List of Laboratory/Learning Resources Required:

Sr. No.	Equipment Name with Broad Specifications
1	Muffle furnace Maximum Operating Temperatures: 1200 °C Heating element: Kanthal wire microprocessor based PID temperature controller
2	Carburizing furnace Maximum Operating Temperatures: 1500 °C
3	Induction Hardening Machine
4	Metallography Specimen preparation set up
5	Double Disc Polishing Machine, Electrolytic polishing and etching machine
6	Metallurgical Microscope Magnification: 1000 X
7	Image Analyzer
8	Rockwell/Brinell/Digital Portable Hardness Testing Machine
9	Jominy End Quench set up
10	Magnetic particle testing Machine / Ultrasonic testing Machine

Suggested Project List:

1. Study the effect of annealing and normalizing on microstructure and mechanical properties of medium carbon steel.
2. Study the effect of hardening and tempering on microstructure and mechanical properties of medium carbon steel.
3. Study the effect of precipitation hardening on aluminum alloy.
4. Compare surface hardening methods based on process and applications.
5. Make a report on “Effect of Full annealing on Hypo Eutectoid steel, Eutectoid steel and Hyper Eutectoid Steel.”
6. Examine and draw microstructure of same steel in different Heat-treated conditions.
7. Make the list of steel which are not used in heat treated condition.
8. Study various defects occurs on specimen after heat treatment process.



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Suggested Activities for Students:

1. Visit to a Heat Treatment Plant / Industry

Observe industrial heat treatment processes such as annealing, hardening, tempering, case hardening. Prepare a report detailing different furnaces, temperature control systems, and safety protocols.

2. Case Study: Failure Due to Improper Heat Treatment

Research or present a real-world case where improper heat treatment led to component failure. Discuss the cause, consequences, and lessons learned.

3. Prepare a Heat Treatment Chart

Draw or compile Time-Temperature-Transformation (TTT) and Continuous Cooling Transformation (CCT) diagrams. Identify and label critical transformation points.

4. Group Presentation on Surface Hardening Techniques

Topics like carburizing, nitriding, flame hardening, induction hardening. Include process details, applications, advantages and disadvantages.

5. Create a Poster / Model

On different types of heat treatment furnaces (muffle, salt bath, vacuum, induction, etc.). Show temperature control, atmosphere types, and safety mechanisms.

6. Compare Heat Treated vs Untreated Parts

Bring machine parts (e.g., gears, shafts) and analyze visual, hardness, and surface differences.

7. Simulation Software Use (if available)

Use heat treatment simulation software/tools (like JMatPro, ThermoCalc) to predict microstructure or hardness.

8. Interview / Interaction with Industry Professionals

Conduct interviews with metallurgists or heat treatment shop supervisors. Present learnings to the class.

9. Quiz / Crossword / Flashcards

Develop educational games or quizzes on heat treatment terms, processes, and applications.

10. Group discussion on environmental issues and control in the industrial heat treatment.

11. Create data bank of mechanical properties of different grade of steel in as cast and heat-treated condition and compare the difference in both.

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