GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Diploma Engineering

Level: Diploma

Branch: Mechanical Engineering

Subject Code: DI05019061

Subject Name: Thermal Systems and Energy Efficiency

w. e. f. Academic Year:	2026-27
Semester:	5th
Category of the Course:	PEC-04

Prerequisite:	Basic knowledge of thermodynamics, heat transfer, and fluid mechanics, including concepts of energy, properties of fluids, heat exchange mechanisms.
Rationale:	Thermal systems are essential components of industrial operations and account for a major share of energy consumption; therefore, their efficient operation and maintenance are crucial for reducing energy losses, lowering production costs, and minimizing environmental impact. This course provides fundamental knowledge and practical skills related to the principles, working, performance evaluation, and energy efficiency of key thermal systems such as boilers, furnaces, heat exchangers, HVAC systems, and air compressors. It also emphasizes energy conservation techniques and sustainable engineering practices, enabling students to analyze system performance, select appropriate equipment, and recommend energy-saving measures, thereby preparing them to contribute effectively to energy-efficient and environmentally responsible industrial applications.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes
01	Explain the principles of energy conservation and analyze energy flows in thermal systems.
02	Analyze boiler performance and recommend methods to improve efficiency and reduce energy losses.
03	Evaluate furnace performance and propose suitable energy conservation measures.
04	Determine the performance of heat exchangers and air compressors using standard performance parameters.
05	Assess the energy performance of HVAC systems and suggest energy-efficient improvements.

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE(E)	PA(M)	PA (I)	ESE (V)	
03	00	02	04	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Basic Concepts of Energy Conservation and Thermal Systems** 1.1 Energy conservation and its significance. 1.2 Energy conservation in domestic applications: • Refrigerators and air conditioners • Electric heaters, pressure cookers • Lighting and fans • Washing machines, ovens, and televisions 1.3 Overview of the *Energy Conservation Act, 2001* and the schemes introduced by the Bureau of Energy Efficiency under this Act. 1.4 Introduction to energy efficiency in various thermal systems, including: • Steam generation systems • Heat exchangers • HVAC (Heating, Ventilation, and Air Conditioning) systems • Refrigeration systems • Air compressors and pumps 1.5 Introduction to energy audits, including walk-through energy audits.	08	14
2.	**Boiler Performance and Steam Distribution Systems** 2.1 Performance evaluation of a typical boiler system (attached data sheet allowed in examinations): • Indirect method • Direct method 2.2 Energy efficiency measures in boiler systems. 2.3 Introduction to and understanding of steam distribution systems.	10	26

	2.4 Steam traps: working principle, operation, and necessity of the following types: • Float and thermostatic steam traps • Thermodynamic steam traps • Inverted bucket steam traps • Thermostatic steam traps with thermal elements (bellows or bimetallic strip) 2.5 Energy conservation in steam distribution systems.		
3.	**Furnace Systems and Energy Efficiency** 3.1 General Structure, Working, and Applications of Furnaces General structure of a furnace Working principle of a general furnace Applications of furnaces in industry 3.2 Factors Affecting Furnace Efficiency Key parameters influencing furnace efficiency 3.3 Performance Evaluation of Typical Heat Treatment Furnace System i. Direct Method (Input–Output Method) ii. Indirect Method (Heat Loss Method) 3.4 General Fuel Economy / Energy Efficiency Measures in Furnace Systems Energy conservation techniques Methods to improve fuel efficiency	08	14
4.	**Energy Efficiency in Heat Exchangers and Compressed Air Systems** 4.1 4.1 Energy Conservation Measures in Heat Exchangers General energy saving techniques in heat exchangers 4.2 Log Mean Temperature Difference (LMTD) Method Concept of LMTD Calculation of LMTD (without derivation) Parallel flow and cross flow heat exchangers 4.3 Performance Evaluation of Heat Exchangers Using LMTD Method Heat exchanger performance analysis based on LMTD 4.4 Compressed Air Systems and Performance Evaluation Basics of air compressor and Free Air Delivery (FAD) Energy conservation measures in compressed air systems 4.5 Field testing of compressors: Nozzle method Pump-up method	09	20

5.	**HVAC and Refrigeration Systems energy efficiency.** 5.1 Introduction to HVAC and Refrigeration Systems 5.2 Selection Criteria for Refrigeration Systems 5.3 Energy Performance Evaluation of HVAC Systems • Concept of: ○ Ton of Refrigeration (TR) ○ Net Refrigerating Capacity ○ Coefficient of Performance (COP) ○ Energy Efficiency Ratio (EER) ○ kW/TR • Numerical calculations of COP, EER, and kW/TR • Heat load estimation using enthalpy difference and psychrometric chart (simple numericals) 5.4 Cooling Load Estimation for Air Conditioning Systems • Basic concept of cooling load • Load estimation for spaces such as classroom, laboratory, and conference hall *(Conceptual understanding only; data sheets allowed in exams)* 5.5 Energy Conservation in Refrigeration and Air Conditioning Systems • Energy efficiency improvement measures • Operational and design-level conservation techniques 5.6 Energy Performance Evaluation of Fans and Blowers *(As per BEE guidebooks)* • Determination of fan pressure, power input, and efficiency • Factors affecting performance of fans and blowers	10	26
	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**
14	18	21	11	6	-

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:

1. Bureau of Energy Efficiency (BEE),
Energy Manager Training Manual (Vol. I–IV), Ministry of Power, Government of India.
2. P. K. Nag,
Engineering Thermodynamics, McGraw Hill Education.
3. R. K. Rajput,
Thermal Engineering, Laxmi Publications.
4. S. C. Arora & S. Domkundwar,
A Course in Power Plant Engineering, Dhanpat Rai Publications.
5. B. K. De,
Energy Management, Audit and Conservation, Universities Press.

(b) Open-Source Software and Websites

1. https://nptel.ac.in(Recommended topics, Thermal Engineering, Heat Transfer, Refrigeration & Air Conditioning)
2. https://www.coursera.org (Energy Efficiency, Sustainable Energy, HVAC fundamentals)
3. https://www.edx.org (Thermodynamics, Energy systems)
4. https://beeindia.gov.in Bureau of Energy Efficiency (BEE) (Energy audit guidebooks, Boiler & furnace efficiency, HVAC calculations)
5. http://btech.mit.asia/downloads/svlomte/HT2011.pdf (Heat Transfer Notes)
6. http://powermin.nic.in (Energy Conservation Act)

Suggested Course Practical List:

Sr. No.	Unit No.	Practical Exercises	Approx Hours. required
1	I to V	**1. Preparatory Activity** a) Visit the laboratory/workshop and identify various thermal systems such as heat exchangers, boilers, furnaces, air compressors, pumps, motors, etc. Record their technical specifications along with manufacturer details. b) Compare the prices of various fuels on a common parameter basis (e.g., cost per unit energy). c) Interpret the terms and equations given in the datasheets provided	04
2	II	**Boiler Performance Analysis** a) Calculate boiler losses using given data by: i. Direct method ii. Indirect method b) Prepare a Sankey diagram representing heat distribution. c) Prepare a heat balance sheet. d) List the various instruments required to measure the necessary parameters	06
3	III	**Furnace Performance Analysis** a) Calculate furnace losses using given data by: i. Direct method ii. Indirect method b) Prepare a Sankey diagram representing heat flow. c) Prepare a heat balance sheet. d) List the various instruments required to measure the required	04
4	IV	**Heat Exchanger Performance Analysis** a) Write the technical specifications of any heat exchanger available nearby. b) Determine its performance based on available technical data and tabulate the observations. c) Identify parameters leading to energy losses in heat exchangers and explain their effects. d) Recommend suitable measures for improving energy efficiency.	04

5	V	**Air Conditioning Load Calculation** a) Calculate the air conditioning load for a given classroom or laboratory using provided data such as U-value, TETD, shading coefficient, lighting allowance, SHGF, and standard equipment load (refer BEE guidebooks if required). b) List the instruments required to measure the necessary	06
6	V	**Refrigeration Load and Fan/Blower Efficiency** a) Calculate the load of a domestic refrigerator or any suitable refrigeration system using standard datasheets (data to be provided by the instructor; refer BEE guidebooks if necessary). b) Calculate the efficiency of a fan or blower. c) List the instruments required to measure the required parameters.	04

List of Laboratory/Learning Resources Required: Boilers/ furnaces/ air compressor system/ heat exchangers/ HVAC/ Refrigeration, Pump, Motors, Lighting, etc. available within institute OR nearby area and industries.

Suggested Activities for Students:

1. **Industrial Visit / Virtual Visit**: Boiler plant / HVAC system / compressor room
2. **Demonstration & Lab Observation**: Identify components of thermal systems
3. **Group Discussion**: Topic: Energy conservation methods
4. **Chart Preparation: Sankey** diagram, Heat balance sheet
5. **Case Study Analysis: Real**-life examples of boiler, furnace, HVAC
6. **Guest Lecture** (if possible): By energy auditor / industry expert
7. **Simple Data Collection Activity**: Record temperature, pressure, energy use

Sr. No.	Unit	Unit Name	Activities and Strategies
1	I	Introduction to energy sources and thermal systems.	Demonstration of systems, industrial visits, on-hand practice on available systems.
2	II	Boilers.	Standard data of boiler room and other auxiliaries from real life example, Industrial visits.
3	III	Furnaces.	Standard data of furnace room and other auxiliaries from real life example, Industrial visits, movies.

4	IV	Heat exchangers and air compressors.	Standard data of any heat exchanger from thermal plant and air compressor room as well as air compressor system, Industrial visits.
5	V	HVAC systems.	Standard data of load calculation to compare with the calculated load calculations, industrial visits, demonstration of plants having HVACsystems.

PO1 (Engineering Knowledge): Apply knowledge of mathematics, natural sciences, engineering fundamentals, and an engineering specialization to a wide range of practical procedures and practices

PO2 (Problem Analysis): Identify and analyze well-defined engineering problems and reach substantiated conclusions using codified methods of analysis specific to their field of activity.

PO3 (Design Solutions): Design solutions for well-defined technical problems and assist in the design of systems, components, or processes to meet specified needs, with appropriate consideration for public health and safety, as well as cultural, societal, and environmental factors.

PO4 (Investigation): Conduct investigations of well-defined problems by locating and search relevant codes and catalogues, and by conducting standard tests and measurements.

PO5 (Modern Tools): Apply appropriate techniques, resources, and modern computing, engineering and IT tools to well-defined engineering problems, while being aware of their limitations.

PO6 (Sustainability & Impact): When solving well-defined engineering problems, evaluate sustainable development impacts to: society, the economy, sustainability, health and safety, legal frameworks, and the environment.

PO7 (Ethics): Understand and commit to professional ethics and the norms of technician practice, including compliance with relevant laws. Demonstrate an understanding of the need for diversity and inclusion (DK9).

PO8 (Teamwork): Function effectively as an individual, and as a member or leader in diverse and inclusive teams, in multidisciplinary face-to-face/remote/distributed settings.

PO9 (Communication): Communicate effectively and inclusively on well-defined engineering activities with the engineering community and society at large by comprehending the work of others, documenting one's own work, and giving and receiving clear instructions.

PO10 (Management): Demonstrate awareness of engineering management principles as a member or leader of a technical team and apply them to manage projects in multidisciplinary environments.

PO11 (Lifelong Learning): Recognize the need for, and have the ability for independent updating in the face of specialized technical knowledge

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