

AFFILIATED INSTITUTIONS
ANNA UNIVERSITY, CHENNAI 600 025

REGULATIONS - 2009

II TO IV SEMESTERS (FULL TIME) CURRICULUM AND SYLLABUS

M.E. THERMAL ENGINEERING

SEMESTER II

| CODE NO | COURSE TITLE | L | T | P | C |
|------------------|---|-----------|----------|----------|-----------|
| THEORY | | | | | |
| TE9221 | Cogeneration and Waste Heat Recovery Systems | 3 | 0 | 0 | 3 |
| TE9222 | Instrumentation for Thermal Systems | 3 | 0 | 0 | 3 |
| TE9223 | Environmental Engineering and Pollution Control | 3 | 0 | 0 | 3 |
| E2 | Elective II | 3 | 0 | 0 | 3 |
| E3 | Elective III | 3 | 0 | 0 | 3 |
| E4 | Elective IV | 3 | 0 | 0 | 3 |
| PRACTICAL | | | | | |
| TE 9224 | Seminar I | 0 | 0 | 2 | 1 |
| Total | | 18 | 0 | 2 | 19 |

SEMESTER III

| CODE NO | COURSE TITLE | L | T | P | C |
|------------------|------------------------|----------|----------|-----------|-----------|
| THEORY | | | | | |
| E5 | Elective V | 3 | 0 | 0 | 3 |
| E6 | Elective VI | 3 | 0 | 0 | 3 |
| E7 | Elective VII | 3 | 0 | 0 | 3 |
| PRACTICAL | | | | | |
| TE 9231 | Seminar II | 0 | 0 | 2 | 1 |
| TE 9232 | Project work (Phase I) | 0 | 0 | 12 | 6 |
| Total | | 9 | 0 | 14 | 16 |

SEMESTER IV

| CODE NO | COURSE TITLE | L | T | P | C |
|--------------|-------------------------|----------|----------|-----------|-----------|
| TE 9241 | Project Work (Phase II) | 0 | 0 | 12 | 12 |
| Total | | 0 | 0 | 12 | 12 |

TOTAL CREDIT: 22+19+16+12 = 69

LIST OF ELECTIVES FOR M.E THERMAL ENGINEERING

| CODE NO | COURSE TITLE | L | T | P | C |
|---------|--|---|---|---|---|
| EY9256 | Design of Heat Exchangers | 3 | 0 | 0 | 3 |
| IC9253 | Gas Turbine Power Plants | 3 | 0 | 0 | 3 |
| IC9254 | Space Propulsion | 3 | 0 | 0 | 3 |
| IC9262 | Computational Fluid Dynamics | 3 | 0 | 0 | 3 |
| IC9268 | Fuel Cell Technology | 3 | 0 | 0 | 3 |
| TE9250 | Renewable Energy Systems | 3 | 0 | 0 | 3 |
| TE9251 | Advanced Internal Combustion Engineering | 3 | 0 | 0 | 3 |
| TE9252 | Turbomachines | 3 | 0 | 0 | 3 |
| TE9254 | Cryogenic Engineering | 3 | 0 | 0 | 3 |
| TE9255 | Refrigeration Machinery and components | 3 | 0 | 0 | 3 |
| TE9256 | Fans, Blowers and Compressors | 3 | 0 | 0 | 3 |
| TE9257 | Food Processing, Preservation and Transport | 3 | 0 | 0 | 3 |
| TE9258 | Nuclear Engineering | 3 | 0 | 0 | 3 |
| TE9259 | Industrial Refrigeration Systems | 3 | 0 | 0 | 3 |
| TE9260 | Refrigeration Systems Design | 3 | 0 | 0 | 3 |
| TE9263 | Fluid Flow and Heat Transfer in Engines | 3 | 0 | 0 | 3 |
| TE9264 | Boundary Layer Theory and Turbulence | 3 | 0 | 0 | 3 |
| TE9266 | Design of Thermal Systems | 3 | 0 | 0 | 3 |
| TE9268 | Combustion Engineering | 3 | 0 | 0 | 3 |
| TE9269 | Energy conservation in Thermal Systems | 3 | 0 | 0 | 3 |
| TE9270 | Advanced Power Plant Engineering | 3 | 0 | 0 | 3 |
| TE9271 | Steam Generator Technology | 3 | 0 | 0 | 3 |
| TE9272 | Fluidized Bed Systems | 3 | 0 | 0 | 3 |
| TE9274 | Advanced Thermal Storage Technologies | 3 | 0 | 0 | 3 |

AIM:

To detail on the importance of Total Energy Concept, its advantages and cost effectiveness.

OBJECTIVES:

- To analyze the basic energy generation cycles
- To detail about the concept of cogeneration, its types and probable areas of applications
- To study the significance of waste heat recovery systems and carryout its economic analysis

UNIT I INTRODUCTION 9

Introduction – principles of thermodynamics – cycles – topping – bottoming – combined cycle – organic rankine cycles – performance indices of cogeneration systems – waste heat recovery – sources and types – concept of tri generation.

UNIT II CONGENERATION TECHNOLOGIES 9

Configuration and thermodynamic performance – steam turbine congeneration systems – gas turbine cogeneration systems – reciprocating IC engines cogeneration systems – combined cycles cogeneration systems – advanced cogeneration systems: fuel cell, Stirling engines etc.,

UNIT III ISSUES AND APPLICATIONS OF COGENERATION TECHNOLOGIES 9

Cogeneration plants electrical interconnection issues – utility and cogeneration plant interconnection issues – applications of cogeneration in utility sector – industrial sector – building sector – rural sector – impacts of cogeneration plants – fuel, electricity and environment.

UNIT IV WASTE HEAT RECOVERY SYSTEMS 9

Selection criteria for waste heat recovery technologies – recuperators – Regenerators – economizers – plate heat exchangers – thermic fluid heaters – Waste heat boilers – classification, location, service conditions, design Considerations – fluidized bed heat exchangers – heat pipe exchangers – heat pumps – sorption systems.

UNIT V ECONOMIC ANALYSIS 9

Investment cost – economic concepts – measures of economic performance – procedure for economic analysis – examples – procedure for optimized system selection and design – load curves – sensitivity analysis – regulatory and financial frame work for cogeneration and waste heat recovery systems.

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. Charles H. Butler, Cogeneration, McGraw Hill Book Co., 1984.11
2. EDUCOGEN – The European Educational tool for cogeneration, Second Edition, 2001

REFERENCES:

1. Horlock JH, Cogeneration - Heat and Power, Thermodynamics and Economics, Oxford, 1987.
2. Institute of Fuel, London, Waste Heat Recovery, Chapman & Hall Publishers, London, 1963.
3. Seagate Subrata, Lee SS EDS, Waste Heat Utilization and Management, Hemisphere, Washington, 1983.
4. De Nevers, Noel., Air Pollution Control Engineering, McGrawHill, New York, 1995

TE 9222

INSTRUMENTATION FOR THERMAL SYSTEMS

**L T P C
3 0 0 3**

AIM:

To enhance the knowledge of the students about various measuring instruments, techniques and importance of error and uncertainty analysis.

OBJECTIVES:

- (I) To provide knowledge on various measuring instruments.
- (II) To provide knowledge on advance measurement techniques.
- (III) To understand the various steps involved in error analysis and uncertainty analysis.

| | | |
|---|---|-----------|
| UNIT I | MEASUREMENT CHARACTERISTICS | 12 |
| Instrument Classification, Characteristics of Instruments – Static and dynamic, experimental error analysis, Systematic and random errors, Statistical analysis, Uncertainty, Experimental planning and selection of measuring instruments, Reliability of instruments. | | |
| UNIT II | MICROPROCESSORS AND COMPUTERS IN MEASUREMENT | 5 |
| Data logging and acquisition – use of sensors for error reduction, elements of micro computer interfacing, intelligent instruments in use. | | |
| UNIT III | MEASUREMENT OF PHYSICAL QUANTITIES | 10 |
| Measurement of thermo-physical properties, instruments for measuring temperature, pressure and flow, use of sensors for physical variables. | | |
| UNIT IV | ADVANCE MEASUREMENT TECHNIQUES | 8 |
| Shadowgraph, Schlieren, Interferometer, Laser Doppler Anemometer, Hot wire Anemometer, heat flux sensors, Telemetry in measurement. | | |
| UNIT V | MEASUREMENT ANALYSERS | 10 |
| Orsat apparatus, Gas Analysers, Smoke meters, gas chromatography, spectrometry. | | |

TOTAL : 45 PERIODS

TEXT BOOKS :

1. Holman, J.P., Experimental methods for engineers, McGraw-Hill, 1988.
2. Barnery, Intelligent Instrumentation, Prentice Hall of India, 1988.
3. Prebrashensky, V., Measurements and Instrumentation in Heat Engineering, Vol. 1 and 2, MIR Publishers, 1980.

REFERENCES :

1. Raman, C.S., Sharma, G.R., Mani, V.S.V., Instrumentation Devices and Systems, Tata McGraw-Hill, New Delhi, 1983.
2. Holman, J.P., Experimental methods for engineers, McGraw-Hill, 1958.
3. Barney, Intelligent Instrumentation, Prentice Hall of India, 1988
4. Prebrashensky. V., Measurement and Instrumentation in Heat Engineering, Vol.1 and MIR Publishers, 1980.
5. Raman, C.S. Sharma, G.R., Mani, V.S.V., Instrumentation Devices and Systems, Tata McGraw-Hill, New Delhi, 1983.
6. Doebelin, Measurement System Application and Design, McGraw-Hill, 1978.
7. Morris. A.S, Principles of Measurements and Instrumentation Prentice Hall of India, 1998.

TE 9223**ENVIRONMENTAL ENGINEERING AND POLLUTION
CONTROL****L T P C
3 0 0 3****AIM:**

To create awareness among the student community on anthropogenic degradation of environment and technologies available to limit the degradation.

OBJECTIVES:

- To impart knowledge on the atmosphere and its present condition, global warming and eco-legislations.
- To detail on the sources of air, water and noise pollution and possible solutions for mitigating their degradation.
- To elaborate on the technologies available for generating energy from waste.

UNIT I INTRODUCTION 9

Global atmospheric change – green house effect – Ozone depletion - natural cycles - mass and energy transfer – material balance – environmental chemistry and biology – impacts – environmental. Legislations.

UNIT II AIR POLLUTION 9

Pollutants - sources and effect – air pollution meteorology – atmospheric dispersion – indoor air quality - control methods and equipments - issues in air pollution control – air sampling and measurement.

UNIT III WATER POLLUTION 9

Water resources - water pollutants - characteristics – quality - water treatment systems – waste water treatment - treatment, utilization and disposal of sludge - monitoring compliance with standards.

UNIT IV WASTE MANAGEMENT 9

Sources and Classification – Solid waste – Hazardous waste - Characteristics – Collection and Transportation - Disposal – Processing and Energy Recovery – Waste minimization.

UNIT V OTHER TYPES OF POLLUTION FROM INDUSTRIES 9
Noise pollution and its impact - oil pollution - pesticides - instrumentation for pollution control - water pollution from tanneries and other industries and their control – environment impact assessment for various projects – case studies.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. G.Masters (2003): Introduction to Environmental Engineering and Science Prentice Hall of India Pvt Ltd, New Delhi.
2. H.S.Peavy, D.R..Rowe, G.Tchobanoglous (1985):Environmental Engineering McGraw- Hill BookCompany, NewYork.

REFERENCES:

- 1 H.Ludwig, W.Evans (1991): Manual of Environmental Technology in Developing Countries, . International Book Company, Absecon Highlands, N.J.
2. Arcadio P Sincero and G. A. Sincero, (2002): Environmental Engineering – A Design Approach, Prentice Hall of India Pvt Ltd, New Delhi.

**EY 9256 DESIGN OF HEAT EXCHANGERS L T P C
3 0 0 3**

AIM:

The course is intended to build up necessary background for the design of the various types of heat exchangers.

OBJECTIVE:

- To learn the thermal and stress analysis on various parts of the heat exchangers
- To analyze the sizing and rating of the heat exchangers for various applications

UNIT I FUNDAMENTALS OF HEAT EXCHANGER 9
Temperature distribution and its implications types – shell and tube heat exchangers – regenerators and recuperators – analysis of heat exchangers – LMTD and effectiveness method.

UNIT II FLOW AND STRESS ANALYSIS 9
Effect of turbulence – friction factor – pressure loss – stress in tubes – header sheets and pressure vessels – thermal stresses, shear stresses - types of failures.

UNIT III DESIGN ASPECTS 9
Heat transfer and pressure loss – flow configuration – effect of baffles – effect of deviations from ideality – design of double pipe - finned tube - shell and tube heat exchangers - simulation of heat exchangers.

UNIT IV COMPACT AND PLATE HEAT EXCHANGERS 9
Types – merits and demerits – design of compact heat exchangers, plate heat exchangers – performance influencing parameters - limitations.

AIM

This course aims to introduce numerical modeling and its role in the field of heat and fluid flow, it will enable the students to understand the various discrimination methods and solving methodologies and to create confidence to solve complex problems in the field of heat transfer and fluid dynamics.

OBJECTIVE S:

- To develop finite difference and finite volume discretized forms of the CFD equations.
- To formulate explicit & implicit algorithms for solving the Euler Eqns & Navier Stokes Eqns.

UNIT I GOVERNING DIFFERENTIAL EQUATION AND FINITE DIFFERENCE METHOD 10

Classification, Initial and Boundary conditions, Initial and Boundary value problems. Finite difference method, Central, Forward, Backward difference, Uniform and non-uniform Grids, Numerical Errors, Grid Independence Test.

UNIT II CONDUCTION HEAT TRANSFER 10

Steady one-dimensional conduction, Two and Three dimensional steady state problems, Transient one-dimensional problem, Two-dimensional Transient Problems.

UNIT III INCOMPRESSIBLE FLUID FLOW 10

Governing Equations, Stream Function – Vorticity method, Determination of pressure for viscous flow, SIMPLE Procedure of Patankar and spalding, Computation of Boundary layer flow, Finite difference approach.

UNIT IV CONVECTION HEAT TRANSFER AND FEM 10

Steady One-Dimensional and Two-Dimensional Convection – Diffusion, Unsteady one-dimensional convection – Diffusion, Unsteady two-dimensional convection – Diffusion – Introduction to finite element method – Solution of steady heat conduction by FEM – Incompressible flow – Simulation by FEM.

UNIT V TURBULENCE MODELS 5

Algebraic Models – One equation model, $K - \epsilon$ Models, Standard and High and Low Reynolds number models, Prediction of fluid flow and heat transfer using standard codes.

TOTAL : 45 PERIODS

REFERENCES

1. Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 1995.
2. Ghoshdasdar, P.S., "Computer Simulation of flow and heat transfer" Tata McGraw Hill Publishing Company Ltd., 1998.
3. Subas, V.Patankar "Numerical heat transfer fluid flow", Hemisphere Publishing Corporation, 1980.
4. Taylor, C and Hughes, J.B. "Finite Element Programming of the Navier Stock Equation", Pineridge Press Limited, U.K., 1981.
5. Anderson, D.A., Tannehill, J.I., and Pletcher, R.H., "Computational fluid Mechanic and Heat Transfer " Hemisphere Publishing Corporation, Newyork, USA, 1984.
6. Fletcher, C.A.J. "Computational Techniques for Fluid Dynamics 1" Fundamental and General Techniques, Springer – Verlag, 1987.

7. Fletcher, C.A.J. "Computational Techniques for Fluid Dynamics 2" Specific Techniques for Different Flow Categories, Springer – Verlag, 1987.
8. Bose, T.X., "Numerical Fluid Dynamics" Narosa Publishing House, 1997.

IC 9268

FUEL CELL TECHNOLOGY

**L T P C
3 0 0 3**

OBJECTIVE:

To gain insight about fuel cells, their working principle, types of fuel cells and performance analysis.

UNIT I INTRODUCTION 5
Basic Principles – Classification – Alkaline, Proton Exchange Membrane, Direct Methanol, Phosphoric Acid & Molten Carbonate – Parts – Fuel cell poisoning

UNIT II THERMODYNAMICS 12
Basic Reactions, Heat of reaction, Enthalpy of formation of substances – Enthalpy change of a reacting system – Gibbs free energy of substances – Gibbs free energy change of reacting system – Efficiency – Power, heat due to entropy change, and internal ohmic heating

UNIT III ELECTROCHEMISTRY 13
Nernst equation and open circuit potential, pressure effect, temperature effect – Stoichiometric coefficients and reactants utilization – Mass flow rate calculation – voltage and current in parallel and serial connection – Over-potentials and polarizations – Activation polarization – Tafel equation and exchange current density – Ionic conductivity, catalysts, Temperature and humidification effect, electro-osmotic drag effect

UNIT IV DESIGN & OPTIMISATION 10
Geometries of fuel cells and fuel cell stacks – Rate of Diffusion of reactants – Water flooding and water management – Gas delivery and current collection – Bipolar plates design – Flow uniformity consideration – Optimization of gas delivery and current collection/asymptotic power density-Heat Removal from Stack

UNIT V APPLICATIONS 5
Automotive applications & issues – Micro fuel cells & Portable power – Distributed & Stationary power.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Fuel Cell Systems Explained, James Larminie and Andrew Dicks, 2nd Edition, John Wiley & Sons Inc., 2000.
2. PEM Fuel Cells Theory and Practice, Frano Barbir, Elsevier Academic Press, 2005.
3. Fuel Cell Technology Handbook, Gregor Hoogers, SAE International, 2003.

REFERENCES :

1. Fuel Cell principles and Applications, B Viswanathan and M Aulice Scibioh, Universities Press, 2006.
2. Hydrogen and Fuel Cells, Bent Sorenson, Elsevier Academic Press, 2005

UNIT I INTRODUCTION**7**

World energy use – Reserves of energy resources – Environmental aspects of energy utilisation – Renewable energy scenario in India – Potentials – Achievements – Applications.

UNIT II SOLAR ENERGY**10**

Solar thermal – Flat plate and concentrating collectors – Solar heating and cooling techniques – Solar desalination – Solar Pond – Solar cooker – Solar thermal power plant – Solar photo voltaic conversion – Solar cells – PV applications.

UNIT III WIND ENERGY**8**

Wind data and energy estimation – Types of wind energy systems – Performance – Details of wind turbine generator – Safety and Environmental Aspects.

UNIT IV BIOMASS ENERGY**8**

Biomass direct combustion – Biomass gasifier – Biogas plant – Ethanol production – Bio diesel – Cogeneration – Biomass applications.

UNIT V OTHER RENEWABLE ENERGY SOURCES**12**

Tidal energy – Wave energy – Open and closed OTEC Cycles – Small hydro – Geothermal energy – Fuel cell systems.

TOTAL : 45 PERIODS**TEXT BOOKS**

1. G.D. Rai, Non Conventional Energy Sources, Khanna Publishers, New Delhi, 1999.
2. S.P. Sukhatme, Solar Energy, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1997.

REFERENCES

1. Godfrey Boyle, Renewable Energy, Power for a Sustainable Future, Oxford University Press, U.K, 1996.
2. Twidell, J.W. & Weir, A., Renewable Energy Sources, EFN Spon Ltd., UK, 1986.
3. G.N. Tiwari, Solar Energy – Fundamentals Design, Modelling and applications, Narosa Publishing House, New Delhi, 2002.
4. L.L. Freris, Wind Energy Conversion systems, Prentice Hall, UK, 1990.
5. Johnson Gary, L., Wind Energy Systems, Prentice Hall, New York, 1985.

UNIT I SPARK IGNITION ENGINES**9**

Spark ignition Engine mixture requirements – Fuel – Injection systems – Monopoint, Multipoint injection, Direct injection – Stages of combustion – Normal and abnormal combustion – factors affecting knock – Combustion chambers.

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|--|--|---------------------------|
| UNIT II | COMPRESSION IGNITION ENGINES | 9 |
| States of combustion in C.I. Engine – Direct and indirect injection systems – Combustion chambers – Fuel spray behaviour – spray structure, spray penetration and evaporation – air motion – Introduction to Turbo charging. | | |
| UNIT III | POLLUTANT FORMATION AND CONTROL | 9 |
| Pollutant – Sources – Formation of carbon monoxide, Unburnt hydrocarbon, NO _x , Smoke and Particulate matter – Methods of controlling Emissions – Catalytic converters and Particulate Traps – Methods of measurements and Introduction to emission norms and Driving cycles. | | |
| UNIT IV | ALTERNATIVE FUELS | 9 |
| Alcohol, Hydrogen, Natural Gas and Liquefied Petroleum Gas- Properties, Suitability, Merits and Demerits as fuels, Engine Modifications. | | |
| UNIT V | RECENT TRENDS | 9 |
| Lean Burn Engines – Stratified charge Engines – homogeneous charge compression ignition engines – Plasma Ignition – Measurement techniques – laser Doppler, Anemometry. | | |
| | | TOTAL : 45 PERIODS |

TEXT BOOK

1. K.K. Ramalingam, Internal Combustion Engine Fundamentals, Scitech Publications, 2002.

REFERENCE BOOKS

1. R.B.Mathur and R.P. Sharma, Internal combustion Engines.
2. V. Ganesan, Int. Combustion Engines, II Edition, TMH, 2002.
3. Duffy Smith, auto fuel Systems, The Good Heart Willox Company, Inc., 198

TE 9252

TURBOMACHINES

L T P C
3 0 0 3

AIM:

To instil the working principles, performance and applications of Turbomachines in the minds of the students.

OBJECTIVES:

- To introduce the energy transfer process in Turbomachines and governing equations of various forms.
- To understand the structural and functional aspects of major components of Turbomachines.
- To understand the applications of Turbomachines to gas turbine power plants and aerospace propulsion.

UNIT I INTRODUCTION 12

Basics of isentropic flow – diffuser and nozzle configurations - static and stagnation properties – area ratio – mass flow rate – critical properties - operating characteristics of diffuser and Nozzle. Various types of subsonic and supersonic inlets. Basics of Fanno and Rayleigh flow. Basics of normal and oblique shock waves. Use of gas tables. Energy transfer between fluid and rotor velocity triangles for a generalized turbomachine - methods of representing velocity diagrams - Euler turbine equation and its different forms - degree of reaction in turbo-machines – various efficiencies – isentropic, mechanical, thermal, polytropic etc.

| | | |
|--|---|----------|
| UNIT II | CENTRIFUGAL AND AXIAL FLOW COMPRESSORS | 9 |
| Centrifugal compressor - configuration and working – slip factor - work input factor – ideal and actual work - pressure coefficient - pressure ratio. Axial flow compressor – geometry and working – velocity diagrams – ideal and actual work – stage pressure ratio - free vortex theory – performance curves. | | |
| UNIT III | COMBUSTION CHAMBER | 6 |
| Basics of combustion and chamber – chamber arrangements - flame stability – fuel injection nozzles. Swirl for stability - cooling of combustion chamber. | | |
| UNIT IV | AXIAL AND RADIAL FLOW TURBINES | 9 |
| Elementary theory of axial flow turbines - stage parameters- multi-staging - stage loading and flow coefficients - degree of reaction - stage temperature and pressure ratios – single and twin spool arrangements – performance. Matching of components. Blade Cooling. Radial flow turbines. | | |
| UNIT V | GAS TURBINE AND JET ENGINE CYCLES | 9 |
| Gas turbine cycle analysis – simple and actual – Reheater, Regenerator and Intercooled cycles. Working principles of Turbojet, Turbofan, Turbo-prop, Ramjet, Scramjet and Pulsejet Engines and cycle analysis – thrust, specific impulse, sfc, thermal and propulsive efficiencies. | | |

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Khajuria P.R and Dubey S.P., Gas Turbines and Propulsive Systems, Dhanpat Rai Publications, 2003.
2. Ganesan, V. Gas Turbines, Tata McGrawHill, 1999.

REFERENCES:

1. Cohen, H., Rogers, G F C and Saravanmotto, H I H, Gas Turbine Theory, John Wiley, 5th Edition 2001.
2. Hill P G and Peterson C R, Mechanics and Thermodynamics of Propulsion, Addition- Wesley, 1970.
3. Mattingly J D, Elements of Gas turbine Propulsion, McGraw Hill, 1st Edition. 1997.

TE 9254

CRYOGENIC ENGINEERING

**L T P C
3 0 0 3**

| | | |
|--|----------------------------|-----------|
| UNIT I | INTRODUCTION | 8 |
| Insight on Cryogenics, Properties of Cryogenic fluids, Material properties at Cryogenic Temperatures. Applications of Cryogenics in Space Programs, Superconductivity, Cryo Metallurgy, Medical applications. | | |
| UNIT II | LIQUEFACTION CYCLES | 10 |
| Carnot Liquefaction Cycle, F.O.M. and Yield of Liquefaction Cycles. Inversion Curve - Joule Thomson Effect. Linde Hampson Cycle, Precooled Linde Hampson Cycle, Claudes Cycle Dual Cycle, Ortho-Para hydrogen conversion, Eollins cycle, Simpson cycle, Critical Components in Liquefaction Systems. | | |

UNIT III SEPARATION OF CRYOGENIC GASES 9
Binary Mixtures, T-C and H-C Diagrams, Principle of Rectification, Rectification Column Analysis - McCabe Thiele Method. Adsorption Systems for purification.

UNIT IV CRYOGENIC REFRIGERATORS 8
J.T.Cryocoolers, Stirling Cycle Refrigerators, G.M.Cryocoolers, Pulse Tube Refrigerators Regenerators used in Cryogenic Refrigerators, Dilution refrigerators, Magnetic Refrigerators

UNIT V HANDLING OF CRYOGENS 10
Cryogenic Dewar, Cryogenic Transfer Lines. Insulations used in Cryogenic Systems, Instrumentation to measure Flow, Level and Temperature.

TOTAL : 45 PERIODS

REFERENCES:

1. Klaus D. Timmerhaus and Thomas M. Flynn, Cryogenic Process Engineering, Plenum Press, New York, 1989
2. Randall F. Barron, Cryogenic Systems, McGraw-Hill, 1985.
3. Scott R.B., Cryogenic Engineering, Van Nostrand and Co., 1962.
4. Herald Weinstock, Cryogenic Technology, 1969.
5. Robert W. Vance, Cryogenic Technology, Johnwiley & Sons, Inc., New York, London.

WEB REFERENCES:

1. www.nasa.gov
2. www.cryogenicsociety.org/
3. www.iifiir.org/
4. www.linde.com
5. www.airliquide.com/
6. www.cern.ch
7. www.nist.gov

TE 9255 REFRIGERATION MACHINERY AND COMPONENTS L T P C
3 0 0 3

UNIT I REFRIGERANT COMPRESSORS 9
Hermetic compressors - Reciprocating, Rotary, Scroll Compressors, Open type compressors - Reciprocating, Centrifugal, Screw Compressors. Semi hermetic compressors - Construction, working and Energy Efficiency aspects. Applications of each type.

UNIT II DESIGN OF CONDENSERS 10
Estimation of heat transfer coefficient, Fouling factor, Friction factor. Design procedures, Wilson plots, Designing different types of condensers, BIS Standards, Optimisation studies.

UNIT III DESIGN OF EVAPORATORS 10
Different types of evaporators, Design procedure, Selection procedure, Thermal Stress calculations, Matching of components, Design of evaporative condensers.

UNIT IV REFRIGERATION SYSTEM COMPONENTS 9
 Evaporators and condensers - Different types, capacity control, circuitry, Oil return, Oil separators - Different types Refrigerant driers strainers, Receivers, Accumulators, Low pressure receivers, Air Washers, Spray ponds.

UNIT V SYSTEM ACCESSORIES AND CONTROLS 7
 Refrigerant Pumps, Cooling Tower fans, Compressor Motor protection devices, Oil equalising in multiple evaporators. Different Defrosting and capacity control methods and their implications - Testing of Air conditioners, Refrigerators, Visicoolers, Cold rooms, Calorimetric tests.

TOTAL : 45 PERIODS

REFERENCES:

- 1) Chlumsky "Reciprocating & Rotary compressors", SNTL Publishers for Technical literature, 1965.
- 2) Hains, J.B, " automatic Control of Heating & Airconditioning" Mc Graw Hill, 1981.
- 3) Althose, A.D. & Turnquist, C.H. " Modern Refrigeration and Airconditioning" Good Heart - Wilcox Co. Inc., 1985.
- 4) Recent release of BIS Code for relevant testing practice.
- 5) ASHRAE Hand book : Equipments, 1998
- 6) Cooper &Williams, B. " Commercial, Industrial, Institutional Refrigeration, Design, Installation and Trouble Shooting " Eagle Wood Cliffs (NT) Prentice Hall, 1989.
- 7) <http://www.chensources.com/ctowers22.shtml>
- 8) <http://www.fortunecity.com/campus/german/201/ctowers.html>
- 9) <http://www.aquasystemsinsc.com/metric-files.html>
- 10) <http://www.ori.org>
- 11) <http://confex.com/store/ashrae/index-features.html>

**TE 9256 FANS, BLOWERS & COMPRESSORS L T P C
 3 0 0 3**

UNIT I PRINCIPLES OF TURBO MACHINERY 10
 Introduction to turbo machines - Transfer of energy to fluids - Performance characteristics - fan laws - Dimensionless parameters - Specific speed - selection of centrifugal, axial, and mixed flow machines.

UNIT II ANALYSIS OF CENTRIFUGAL BLOWERS AND FANS 10
 Centrifugal Blowers: Theoretical characteristic curves, Eulers characteristics and Eulers velocity triangles, losses and hydraulic efficiency, flow through impeller inlet volute, diffusers, leakage disc friction mechanical losses multivane impellers of impulse type, crossflow fans.

UNIT III ANALYSIS OF COMPRESSOR 14
 Rotor design airfoil theory, vortex theory, cascade effects, degree of reaction, blade twist stage design, surge and stall, stator and casing, mixed flow impellers.

UNIT IV TESTING AND CONTROL OF FANS 5
 Fan testing, noise control, materials and components blower regulation, speed control, throttling, control at discharge and inlet.

UNIT V APPLICATIONS OF BLOWERS**6**

Applications of blowers, induced and forced draft fans for air conditioning plants, cooling towers, ventilation systems, booster systems.

TOTAL : 45 PERIODS**REFERENCES**

1. S.M. Yahya, " Fundamentals of Compressible Flow ", New Age International (P)Limited, New Delhi, 1996
2. Stepanoff A.J., Turboblowers, John Wiley & Sons, 1970.
3. Brunoeck, Fans, Pergamon Press, 1973.
4. Austin H. Church, Centrifugal pumps and blowers, John Wiley and Sons, 1980.
5. Dixon, Fluid Mechanics, Thermodynamics of turbomachinery Pergamon Press, 1984.
6. Dixon, Worked examples in turbomachinery, Pergamon Press, 1984.

WEB REFERENCES

1. <http://www.petropager.com>
2. <http://www.tamil.org>
- 3 <http://www.erichson.com>
- 4 .<http://www.apgate.com>

TE 9257**FOOD PROCESSING, PRESERVATION AND TRANSPORT****L T P C
3 0 0 3****UNIT I INTRODUCTION:****9**

Microbiology of Food Products, Mechanism of food spoilage critical microbial growth requirements, Design for control of micro organisms, The role of HACCP, Sanitation, Regulation and standards

UNIT II PROCESSING & PRESERVATION**12**

Thermodynamic properties and Transfer properties, Water content, Initial freezing temperature, Ice fraction, Transpiration of fresh fruits & vegetables, Food processing techniques for Dairy products, Poultry, Meat, Fruits & Vegetables

UNIT III FREEZING & DRYING**12**

Precooling, Freeze drying principles, Cold storage & freezers, Freezing drying limitations, Irradiation techniques, Cryofreezing, Numerical and analytical methods in estimating Freezing, Thawing times, Energy conservation in food industry.

UNIT IV COLD STORAGE DESIGN & INSTRUMENTATION**7**

Initial building consideration, Building design, Specialized storage facility, Construction methods, Refrigeration systems, Insulation techniques, Control & instrumentation, Fire protection, Inspection & maintenance

UNIT V TRANSPORT**5**

Refrigerated transportation, Refrigerated containers & trucks, Design features, Piping & Role of cryogenics in freezing & transport

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Glasstone, S. and Sesonske, A, Nuclear Reactor Engineering, 3rd Edition, Von Nostrand, 1984.
2. Duderstadt, J.J. and Hamilton, L.J., Nuclear Reactor Analysis, John Wiley, 1976.

REFERENCES:

1. Lamarsh, J.R., Introduction to Nuclear Reactor Theory, Wesley, 1996.
2. Walter, A.E. and Reynolds, A.B., Fast Breeder Reactor, Pergamon Press, 1981.
3. Winterton, R.H.S., Thermal Design of Nuclear Reactors, Pergamon Press, 1981.

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| TE 9259 | INDUSTRIAL REFRIGERATION SYSTEMS | L T P C |
| | | 3 0 0 3 |

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| UNIT I | INTRODUCTION | | 6 |
| | Introduction to industrial refrigeration - difference from conventional system - applications - industrial and comfort air - conditioning - conditions for high COP | | |

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| UNIT II | COMPRESSORS | | 10 |
| | Reciprocating and screw compressor: Multistage industrial applications, cylinder arrangement, cooling methods - oil injection and refrigeration injection, capacity regulations - Economizers. | | |

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| UNIT III | EVAPORATORS AND CONDENSERS | | 12 |
| | Types of Evaporators, Liquid circulation: Mechanical pumping and gas pumping - advantage and disadvantage of liquid re-circulation - circulation ratio - top feed and bottom feed refrigerant - Net Positive Suction Head (NPSH) - two pumping vessel system - suction risers – design - piping loses. Different Industrial Condensers arrangement, Evaporators-Types and arrangement, liquid circulation, type of feed, refrigerant piping design , functional aspects. Lubricating oil: types - physical properties, types of circulation and oil separator | | |

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| UNIT IV | VESSELS | | 8 |
| | Vessels in industrial refrigeration: High pressure receiver - flash tank - liquid and vapour separator - separation enhancers - low pressure receivers - surge drum - surge line accumulator - thermosyphon receiver - oil pots. | | |

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| UNIT V | ENERGY CONSERVATION | | 9 |
| | Energy conservation and design considerations - source of losses - energy efficient components - heat reclaim - thermal storage: ice builder and ice harvester. Insulation: critical thickness - insulation cost and energy cost - vapour barriers - construction methods of refrigerated spaces. | | |

TOTAL : 45 PERIODS

REFERENCES:

1. Wilbert F.Stoecker, Industrial Refrigeration Hand Book, McGraw-Hill, 1998.
2. ASHRAE Hand Book: Fundamentals, 1997.
3. ASHRAE Hand Book: Refrigeration, 1998.
4. ASHRAE Hand Book: HVAC Systems and Equipment, 1996.
5. Transport properties of SUVA Refrigerants, Du-Pont Chemicals, 1993.

AIM:

To teach the students about Refrigeration System Design concepts.

OBJECTIVES:

- Teaching cycle analysis pertaining to Refrigeration systems.
- Teaching performance of system components and their balancing in cycles.

UNIT I REFRIGERATION CYCLES - ANALYSIS 10
Development of Vapor Compression Refrigeration Cycle from Reverse Carnot Cycle-conditions for high COP-deviations from ideal vapor compression cycle , Multipressure Systems , Cascade Systems-Analysis .

UNIT II MAIN SYSTEM COMPONENTS 12
Compressor- Types , performance , Characteristics of Reciprocating Compressors , Capacity Control , Types of Evaporators & Condensers and their functional aspects , Expansion Devices and their Behavior with fluctuating load.

UNIT III REFRIGERANTS 11
Classification of Refrigerants , Refrigerant properties , Oil Compatibility , Environmental Impact-Montreal / Kyoto protocols-Eco Friendly Refrigerants.
Different Types of Refrigeration Tools , Evacuation and Charging Unit , Recovery and Recycling Unit , Vacuum Pumps.

UNIT IV SYSTEM BALANCING & CONTROLS 6
Estimation of Cooling Load , System Equilibrium and Cycling Controls , Electric Circuits in- Refrigerators , Window A/C , Types of motors , Relays.

UNIT V OTHER REFRIGERATION CYCLES 6
Vapor Absorption Systems-Aqua Ammonia & LiBr Systems, Steam Jet Refrigeration Thermo Electric Refrigeration, Air Refrigeration cycles.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Dossat R.J., Principles of refrigeration, John Wiley, S.I. Version (2001).
2. Stoecker W.F., Refrigeration and Air conditioning, McGraw-Hill Book Company, 1989.

REFERENCES:

1. Jordan and Priester , Refrigeration and Air conditioning 1985.
2. Goshnay W.B., Principles and Refrigeration, Cambridge, University Press, 1985.
3. Langley , Billy C., 'Solid state electronic controls for HVACR' pentice-Hall 1986.

OBJECTIVE:

To visualize fluid in an IC engine, aspects of heat transfer and cooling of components.

UNIT I INTRODUCTION 5
Basic Laws, Newtonian Fluids, Navier – Stokes Equations, Compressible and Incompressible Flows, Stream Functions and velocity Potential, Vorticity Dynamics.

UNIT II TURBULENT BOUNDARY LAYERS 9

Internal Flows – Couette flow – Two-Layer Structure of the velocity Field – Universal Law of the wall – Friction law – Fully developed Internal flows – Chennel Flow, Couettee – Poiseuille flows, Pipe Flow.

UNIT III TURBULENCE AND TURBULENCE MODELS 9

Nature of turbulence – Averaging Procedures – Characteristics of Turbulent Flows – Types of Turbulent Flows – Scales of Turbulence, Prandtl's Mixing length, Two-Equation Models, Low – Reynolds – Number Models, Large – Eddy Simulation.

UNIT IV STATISTICAL THEORY OF TURBULENCE 9

Ensemble Average – Isotropic Turbulence and Homogeneous Turbulence – Kinematics of Isotropic Turbulence – Taylor's Hypothesis – Dynamics of Isotropic Turbulence – Grid Turbulence and decay – Turbulence in Stirred Tanks.

UNIT V TURBULENT FLOWS 9

WALL Turbulent shear flows – Structure of wall flow – Turbulence characteristics of Boundary layer – Free Turbulence shear flows – Jets and wakes – Plane and axi-symmetric flows.

TOTAL : 45 PERIODS

TEXT BOOKS:

1. G. Biswas and E. Eswaran, Turbulent Flows, Fundamentals, Experiments and Modelling, Narosa Publishing House, 2002.
2. H. Schlichting and Klaus Gersten, Boundary Layer Theory, Springer 2000.
3. R.J. Garde, Turbulent Flow, New Age International (p) Limited, Publishers, 2000.

**TE 9266 DESIGN OF THERMAL SYSTEMS L T P C
3 0 0 3**

AIM:

To provide review and use knowledge from thermodynamics, heat transfer and fluid mechanics, modeling and stimulation techniques for thermal system component analysis and their synthesis in integral engineering systems and processes

OBJECTIVES:

- To learn basic principles underlying piping, pumping, heat exchangers; modeling and optimization in design of thermal systems.
- To develop representational modes of real processes and systems.
- To optimization concerning design of thermal systems.

UNIT I DESIGN CONCEPTS 9

Design Principles , Workable Systems , Optimal Systems , Matching of System Components , Economic Analysis , Depreciation , Gradient Present Worth factor.

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| UNIT II | MATHEMATICAL MODELLING | 9 |
| Equation Fitting , Nomography , Empirical Equation , Regression Analysis , Different Modes of Mathematical Models , Selection, Computer Programmes for Models. | | |
| UNIT III | MODELLING THERMAL EQUIPMENTS | 10 |
| Modelling Heat Exchangers , Evaporators , Condensers , Absorption and Rectification Columns , Compressors , Pumps , Simulation Studies , Information Flow Diagram , Solution Procedures. | | |
| UNIT IV | OPTIMIZATION | 12 |
| Objective Function Formulation , Constraint Equations , Mathematical Formulation , Calculus Method , Dynamic Programming , Search Methods , ANN and Genetic Algorithm. | | |
| UNIT V | DYNAMIC BEHAVIOUR | 5 |
| Steady state Simulation , Laplace Transformation , Feedback Control Loops , Stability Analysis , Non-Linearities. | | |

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Stoecker W. F., Design of Thermal Systems , McGraw Hill Edition , 1989.
2. Bejan A., George Tsatsaronis , Michael J. Moran , Thermal Design and Optimization , Wiley , 1996.

REFERENCES:

1. Kaput J. N., Mathematical Modelling , Wiley Eastern Ltd , New York , 1989.
2. Yogesh Jaluria , Design and Optimization of Thermal Systems , CRC Press , 2007.
3. Rao S. S., Engineering Optimization Theory and Practice , New Age Publishers , 2000.

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| TE 9268 | COMBUSTION ENGINEERING | L T P C |
| | | 3 0 0 3 |

AIM :

To introduce the types, characterization and properties of fuel, Also to discuss the principles of combustion with emphasis on engineering applications.

OBJECTIVES :

- To provide information on various types of fuels, their property and characterization.
- To understand the thermodynamics and kinetics of combustion.
- To understand and analyze the combustion of various fuels.

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| UNIT I | INTRODUCTION | 9 |
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Historical perspective of combustion science – perspective of fuels and combustion technology. Types and general characteristics of fuels – proximate and ultimate analysis of fuels. ROM, DMMF, DAF and bone dry basis. Moisture and heating value determination – gross and net heating values – calorimetry, DuLong’s formula for HV estimation, Flue gas analysis – Orsat apparatus.

UNIT II FUEL TYPES**9****Solid Fuels :**

Peat – coal – biomass – wood waste – agro fuels – refuse derived solid fuel – testing of solid fuels. Bulk and apparent density – storage – washability – coking and caking coals.

Liquid Fuels :

Refining – molecular structure – liquid fuel types and their characteristics – fuel quality. Liquefaction of solid fuels.

Gaseous Fuels :

Classification and characterization.

UNIT III THERMODYNAMICS AND KINETICS OF COMBUSTION**9**

Properties of mixture – combustion stoichiometry – chemical energy – chemical equilibrium and criteria – properties of combustion products. First law combustion calculations – adiabatic flame temperature (analytical and graphical methods) – simple second law analysis. Elementary reactions – chain reactions – pre-ignition kinetics – global reactions – kinetics – reaction at solid surface.

UNIT IV COMBUSTION OF SOLID FUELS**8**

Drying - devolatilization - char combustion. Fixed bed combustion - suspension burning - fluidized bed combustion.

UNIT V COMBUSTION OF LIQUID AND GASEOUS FUELS**10**

Spray formation and droplet behaviour - oil fired furnace combustion - gas turbine spray combustion – direct and indirect Injection combustion in IC engines. Energy balance and furnace efficiency – gas burner types - pulse combustion furnace. Premixed charge engine combustion. Detonation of gaseous mixtures.

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. Kuo, K.K., Principles of Combustion, 2nd Edition, John Wiley and Sons, Inc., 2005.
2. Annamalai, K and Puri, I.K, Combustion science and Engineering, CRC Press, 2007.

REFERENCES:

1. Borman, G.L. and Ragland, K.W., Combustion Engineering, McGrawHill International Editions, 1998.
2. Samir Sarkar, Fuels and Combustion, 2nd Edition, Orient Longman, 1990
3. Sharma SP and Mohan Chander, Fuels and Combustion, Tata Mcgraw Hill, 1984.
4. Bhatt, B.I and Vora, S.M., Stoichiometry, 2nd Edition, Tata Mcgraw Hill, 1996
5. Clive Davis, Calculations in Furnace Technology, Pergamon Press, Oxford, 1970.

TE 9269 ENERGY CONSERVATION IN THERMAL SYSTEMS**L T P C
3 0 0 3****AIM :**

To course is intended to introduce principles of energy auditing and to provide measures for energy conservation in thermal applications

OBJECTIVES:

To learn the present energy scenario and the need for energy conservation

- To learn the instruments suitable for energy auditing
- To study the various measures for energy conservation and financial implications for various thermal utilities

UNIT I INTRODUCTION 10

Energy Scenario – world and India. Energy Resources Availability in India. Energy consumption pattern. Energy conservation potential in various Industries and commercial establishments. Energy intensive industries – an overview. Energy conservation and energy efficiency – needs and advantages. Energy auditing – types, methodologies, barriers. Role of energy manager – Energy audit questionnaire – energy Conservation Act 2003.

UNIT II INSTRUMENTS FOR ENERGY AUDITING 8

Instrument characteristics – sensitivity, readability, accuracy, precision, hysteresis. Error and calibration. Measurement of flow, velocity, pressure, temperature, speed, Lux, power and humidity. Analysis of stack, water quality, power and fuel quality.

UNIT III THERMAL UTILITIES: OPERATION AND ENERGY CONSERVATION 10

- (i) Boilers (ii) Thermic Fluid Heaters (iii) Furnaces
(iv) Waste Heat Recovery Systems (v) Thermal Storage

UNIT IV THERMAL ENERGY TRANSMISSION / PROTECTION SYSTEMS 7

Steam traps – refractories – optimum insulation thickness – insulation – piping design

UNIT V FINANCIAL MANAGEMENT 10

Investment – need, appraisal and criteria, financial analysis techniques – break even analysis – simple pay back period, return on investment, net present value, internal rate of return, cash flows, DSCR, financing options, ESCO concept.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Smith, CB Energy Management Principles, Pergamon Press, New York, 1981
2. Hamies, Energy Auditing and Conservation; Methods Measurements, Management and Case study, Hemisphere, Washington, 1980

REFERENCES:

1. Trivedi, PR, Jolka KR, Energy Management, Commonwealth Publication, New Delhi, 1997
2. Write, Larry C, Industrial Energy Management and Utilization, Hemisphere Publishers, Washington, 1988
3. Diamant, RME, Total Energy, Pergamon, Oxford, 1970
4. Handbook on Energy Efficiency, TERI, New Delhi, 2001
5. Guide book for National Certification Examination for Energy Managers and Auditors (Could be downloaded from www.energymanagertraining.com)

AIM:

To introduce the advances in operations and applications of different types of power plants.

OBJECTIVES:

- To understand the energy scenario and the environmental issues related to the power plants.
- To understand the various improvements possible in steam turbine, gas turbine and combined cycle power plants.
- To study the advances in nuclear and MHD power plants.

UNIT I INTRODUCTION 6

Overview of the Indian power sector – load curves for various applications – types of power plants – merits and demerits – criteria for comparison and selection.

UNIT II STEAM AND GAS TURBINE POWER PLANTS 12

Rankine Cycle – Performance – thermodynamic analysis of cycles. Cycle improvements. Superheaters, reheaters – condenser and feed water heaters – operation and performance – layouts. Gas turbine cycles – optimization – thermodynamic analysis of cycles – cycle improvements – multi spool arrangement. Intercoolers, reheaters, regenerators – operation and performance – layouts.

UNIT III ADVANCED POWER CYCLES 10

Binary and combined cycle – coupled cycles – comparative analysis of combined heat and power cycles – IGCC – AFBC/PFBC cycles – Thermionic steam power plant.

UNIT IV NUCLEAR AND MHD POWER PLANTS 10

Overview of Nuclear power plants – radioactivity – fission process – reaction rates – diffusion theory, elastic scattering and slowing down – criticality calculations – critical heat flux – power reactors – nuclear safety. MHD and MHD – steam power plants.

UNIT V ENVIRONMENTAL ISSUES 7

Air and water pollution – acid rains – thermal pollution – radioactive pollution – standardization – methods of control. Environmental legislations / Government policies. Economics of power plants.

TOTAL : 45 PERIODS

TEXT BOOKS:

1. Nag, P.K., Power Plant Engineering, Tata Mcgraw Hill Publishing Co Ltd, New Delhi, 1998.
2. Arora and Domkundwar, A course in power Plant Engineering, Dhanpat Rai and CO, 2004.

REFERENCES:

1. Haywood, R.W., Analysis of Engineering Cycles, 4th Edition, Pergamon Press, Oxford, 1991.
2. Wood, A.J., Wollenberg, B.F., Power Generation, operation and control, John Wiley, New York, 1984.
3. Gill, A.B., Power Plant Performance, Butterworths, 1984.
4. Lamarsh, J.R., Introduction to Nuclear Engg. 2nd edition, Addison-Wesley, 1983.

AIM:

To understand the types, working of steam generator and their major components, along with design principles and calculations.

OBJECTIVES:

- To educate the students on the types of boilers with their constructional and functional significance.
- To understand the working and design of coal preparation units and boilers.
- To introduce the concept of heat transfer surfaces and the boiler design.

UNIT I INTRODUCTION 10

Boilers – components – classification – general design considerations – boiler specifications. Fuel stoichiometry calculations – enthalpy calculation of air and combustion products – heat balance.

UNIT II COAL PREPARATION SYSTEM OF BOILERS 8

Pulverizing properties of coal – air system for pulverization – size – reducing machines. Design of coal preparation system for PC Boilers – fuel-feeding arrangements

UNIT III DESIGN OF BURNERS 8

Design of oil supply system – tangential fired burners – oil atomizers – air registers – design principles of oil fired boilers

UNIT IV BOILERS FURNACE DESIGN 9

General design Principles – flame Emissivity – heat transfer calculation for PC Boiler furnace – water wall arrangement – furnace emissivity – distribution of heat load in furnace. Fluidized bed boilers – major features of fluidized bed boilers – basic design principles.

UNIT V DESIGN OF CONVECTIVE HEAT TRANSFER SURFACE 10

Design of economizer – superheater – reheater – air preheater. Temperature control in superheaters and reheaters.

TOTAL: 45 PERIODS**TEXT BOOKS:**

1. Prabir Basu, Cen Kefa and Louis Jestin, Boilers and Burners: Design and Theory, Springer 2000.
2. Ganapathy, V., Industrial Boilers and Heat Recovery Steam Generators, Marcel Dekker Ink 2003

REFERENCES:

1. David Gunn and Robert Horton, Industrial Boilers, Longman Scientific and Technical Publication, 1986
2. Carl Schields, Boilers: Type, Characteristics and Functions, McGraw Hill Publishers, 1982
3. Howard, J.R., Fluidized Bed Technology: Principles and Applications, Adam Hilger, New York, 1983.

AIM:

To inspire the students with the theories of fluidization, heat transfer and design for various applications.

OBJECTIVES:

- To introduce the concepts of fluidization and heat transfer in fluidized beds.
- To understand the design principles and apply the same for industrial applications.

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| UNIT I | FLUIDIZED BED BEHAVIOUR | 12 |
| Characterization of bed particles – comparison of different methods of gas – solid contacts. Fluidization phenomena – regimes of fluidization – bed pressure drop curve. Two phase and well-mixed theory of fluidization. Particle entrainment and elutriation – unique features of circulating fluidized beds. | | |
| UNIT II | HEAT TRANSFER | 6 |
| Different modes of heat transfer in fluidized bed – to wall heat transfer – gas to solid heat transfer – radiant heat transfer – heat transfer to immersed surfaces. Methods for improvement – external heat exchangers – heat transfer and part load operations. | | |
| UNIT III | COMBUSTION AND GASIFICATION | 6 |
| Fluidized bed combustion and gasification – stages of combustion of particles – performance – start-up methods. Pressurized fluidized beds. | | |
| UNIT IV | DESIGN CONSIDERATIONS | 9 |
| Design of distributors – stoichiometric calculations – heat and mass balance – furnace design – design of heating surfaces – gas solid separators. | | |
| UNIT V | INDUSTRIAL APPLICATIONS | 12 |
| Physical operations like transportation, mixing of fine powders, heat exchange, coating, drying and sizing. Cracking and reforming of hydrocarbons, carbonization, combustion and gasification. Sulphur retention and oxides of nitrogen emission Control. | | |

TOTAL : 45 PERIODS

TEXT BOOKS:

1. Howard, J.R., Fluidized Bed Technology: Principles and Applications, Adam Hilger, New York, 1983.
2. Geldart, D., Gas Fluidization Technology, John Wiley and Sons, 1986.

REFERENCES:

1. Kunii, D and Levespiel, O., Fluidization Engineering, John Wiley and Son Inc, New York, 1969.
2. Howard, J.R. (Ed), Fluidized Beds: Combustion and Applications, Applied Science Publishers, New York, 1983.
3. Botteril, J.S.M., Fluid Bed Heat Transfer, Academic Press, London, 1975.
4. Yates, J.G. Fundamentals of Fluidized bed Chemical Processes, Butterworths, 1983.

AIM:

This course is intended to build up the necessary background to model and analyze the various types of thermal storage systems

OBJECTIVES:

- To learn the various types of thermal storage systems and the storage materials
- To develop the ability to model and analyze the sensible and latent heat storage units
- To study the various applications of thermal storage systems

UNIT I INTRODUCTION**8**

Necessity of thermal storage – types-energy storage devices – comparison of energy storage technologies - seasonal thermal energy storage - storage materials.

UNIT II SENSIBLE HEAT STORAGE SYSTEM**9**

Basic concepts and modeling of heat storage units - modeling of simple water and rock bed storage system – use of TRNSYS – pressurized water storage system for power plant applications – packed beds.

UNIT III REGENERATORS**10**

Parallel flow and counter flow regenerators – finite conductivity model – non – linear model – transient performance – step changes in inlet gas temperature – step changes in gas flow rate – parameterization of transient response – heat storage exchangers.

UNIT IV LATENT HEAT STORAGE SYSTEMS**9**

Modeling of phase change problems – temperature based model - enthalpy model - porous medium approach - conduction dominated phase change – convection dominated phase change.

UNIT V APPLICATIONS**9**

Specific areas of application of energy storage – food preservation – waste heat recovery – solar energy storage – green house heating – power plant applications – drying and heating for process industries.

TOTAL: 45 PERIODS**TEXT BOOK:**

1. Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, John Wiley & Sons 2002.

REFERENCES:

1. Schmidt.F.W and Willmott.A.J, Thermal Storage and Regeneration, Hemisphere Publishing Corporation, 1981.
2. Lunardini.V.J, Heat Transfer in Cold Climates, John Wiley and Sons 1981.