M.Tech. IN MECHANICAL ENGINEERING (ENERGY TECHNOLOGY)

CURRICULUM AND SYLLABUS

(Effect from the Academic Year 2007 – 08)

PONDICHERRY UNIVERSITY

PUDUCHERRY – 605014.

M. TECH. IN MECHANICAL ENGINEERING (ENERGY TECHNOLOGY)

CURRICULUM AND SCHEME OF EXAMINATION

(Total number of credit required for the completion of the programme – 72)

ELIGIBILITY:

M.Tech. in Mechanical Engineering (Energy Technology): Candidates for admission to the first semester of the four semester M.Tech. Course in Mechanical Engineering with specialisation in Energy Technology should have passed B.E/B.Tech in Mechanical / Chemical / Electrical Engineering (with Thermodynamics and Heat & Mass Transfer as electives) (or) an examination of any University or Authority accepted by the Pondicherry University as equivalent thereto, with at least 55% marks in the degree examination or equivalent CGPA.

SEMESTER – I

Sl. No.	Code	Subject	Hours / Week			Credits	Evaluation (marks)		
			L	T	P		Internal	External	Total
1.	ME 901	Advanced Thermodynamics and Heat transfer	3	1	0	4	40	60	100
2.	ME 902	Energy Conversion Systems	3	1	0	4	40	60	100
3.	ME 903	Optimization Techniques	3	1	0	4	40	60	100
4.		Elective – I	3	0	0	3	40	60	100
5.		Elective – II	3	0	0	3	40	60	100
6.	ME 907	Computational Techniques Laboratory	1	0	3	2	50	50	100
						20	250	350	600

SEMESTER – II

Sl. No.	Code	Subject	Hours / Week			Credits	Evaluation (marks)		
			L	T	P		Internal	External	Total
1.	ME 904	Energy Conservation and Management	3	1	0	4	40	60	100
2.	ME 905	Design of Thermal Equipment	3	1	0	4	40	60	100
3.	ME 906	Computational Fluid Dynamics	3	1	0	4	40	60	100
4.		Elective – III	3	0	0	3	40	60	100
5.		Elective – IV	3	0	0	3	40	60	100
6.		Elective – V	3	0	0	3	40	60	100
7.	ME 908	Energy Engineering Laboratory	0	0	3	2	50	50	100
						23	290	410	700

SEMESTER – III

Sl. No.	Code	Subject	Hours / Week			Credits	Evaluation (marks)		
			L	T	P		Internal	External	Total
1.		Elective – VI	3	0	0	3	40	60	100
2.		Elective – VII	3	0	0	3	40	60	100
3.	ME 961	Directed Study	0	0	6	3	100	---	100
4.	ME 909	Dissertation Project (Phase I)	0	0	24	8	200	100	300
						17	380	220	600

SEMESTER – IV

Sl. No.	Code	Subject	Hours / Week			Credits	Evaluation (marks)		
			L	T	P		Internal	External	Total

1.	ME 910	Dissertation Project (Phase II)	0	0	36	12	250	150	400
						12	250	150	400

LIST OF ELECTIVES

Sl. No.	Code	Subject
1.	ME 921	Advanced Fluid Mechanics
2.	ME 922	Alternate Fuels and Their Applications
2.	ME 923	Bio-Energy and Conversion Systems
3.	ME 924	Co-generation Technology
4.	ME 925	Cryogenic Engineering
5.	ME 926	Design of Experiments
6.	ME 927	Direct Energy Conversion
7.	ME 928	Energy Conversion and Environment Pollution
8.	ME 929	Energy Management in Buildings
9.	ME 930	Fluidized Bed Technology
10.	ME 931	Modeling and Simulation of Energy Systems
11.	ME 932	Nuclear Power Engineering
12.	ME 933	Utilization of Solar Energy
13	ME 934	Utilization of Wind and Hydrogen Energies

ME 901 ADVANCED THERMODYNAMICS AND HEAT TRANSFER

Unit - I

I law of thermodynamics analysis for processes & cycles – energy balance equations and their applications. II law of thermodynamics and its corollaries – entropy – II law analysis of processes & cycles – available energy - availability analysis – irreversibility – III law of thermodynamics.

Unit - II

Thermodynamic relationships - Gibb's function - Helmholtz function - thermodynamic potentials – Maxwell relations – Clausius Clapeyron equation – Joule-Thomson coefficient – generalized relations for specific heats, internal energy, enthalpy, and entropy. Fundamental property relations for systems of variable composition – partial molar properties – equilibrium in multiphase system – Gibb's phase rule for non-reactive components.

Unit - III

Conduction - steady state and transient heat conduction – non-uniform conductivity – heat transfer from extended surface. Convection - free and forced convection - concept of boundary layer thickness - hydro dynamic and thermal boundary layer – momentum and energy transfer through boundary layer – energy equations – exact solutions.

Unit - IV

Radiation - radiative heat exchange between surfaces separated by a medium – non-absorbing and absorbing – radiation from gasses, vapour, clouds, and luminous flames. Heat transfer with phase change - condensation and boiling – heat transfer in flow boiling – Heat transfer in two phase flow – heat transfer in high speed flow.

Unit - V

Liquid metal heat transfer – heat transfer in rotating machinery – heat transfer in space power plants systems – heat transfer in solar applications.

Reference Books

1. Michael, J. Moran and Howard, N. Shapiro, Fundamentals of Engineering Thermodynamics, John Wiley & Sons, New York, 1993.
2. Francis, F. Huang, Engineering Thermodynamics - Fundamentals and Application, Macmillan Publishing Co., New York, 1989.
3. Van Wylen and Sonntag, R. E., Fundamentals of Classical Thermodynamics, John Wiley & Sons, 1994.
4. Kenneth Wark Jr., Advanced Thermodynamics for Engineers, McGraw Hill Book Co., 1995.
5. Eckert, E. R. G. and R. M. Drake Jr., Analysis of Heat and Mass Transfer, McGraw Hill Book Co., New York, 1973.
6. Frank P. Incropera and David P. Dewitt., Fundamentals of Heat and Mass Transfer – 4/e, John Wiley & Sons, New York, 2000.
7. Metzgar, D. E. and Afghan, N. H., Heat and Mass Transfer in Rotating Machinery, Hemisphere Publishing Co., 1984

8. Tong, L. S., Boiling Heat Transfer and Two Phase Flow, John Wiley & Sons, New York, 1965.
9. Collier, J.G., Convective Boiling and Condensation, McGraw Hill Book Co., New York, 1972.
10. Sparrow, E. M. and R. D. Cess, Radiation Heat Transfer, Hemisphere Publishing Co., New York, 1978.

ME 902 ENERGY CONVERSION SYSTEMS

Unit - I

Energy classification – Energy sources – Principal sources of energy: conventional and non-conventional sources – bio-mass, fossil fuels, nuclear fuels, solar energy – Energy conversion – prospecting, extraction, resource assessment and their peculiar characteristics.

Unit - II

Production of thermal energy using bio-mass, fossil fuels, nuclear fuels, solar energy – Conversion of thermal energy, electrical energy, electromagnetic energy and hydraulic energy into mechanical energy – Energy conversion system: steam turbines, hydraulic turbines and wind turbines – Energy conversion system cycles.

Unit - III

Production of electrical energy using thermal energy, chemical energy, electromagnetic energy and mechanical energy – Magneto hydrodynamic conversion – introduction – MHD plasmas – analysis of MHD generators – MHD power applications – Batteries – basic concepts – electrochemical principles and reactions – selection and application of batteries – fuel cells – general characteristics – low power fuel cell systems – fuel cell power plants.

Unit - IV

Production of electrical energy using non-conventional sources: solar energy, wind energy, wave energy, tidal energy and ocean thermal energy. Solar thermal energy conversion system – photovoltaic conversion – optical effects of p-n junction – analysis of PV cells – wave energy conversion system – tidal energy conversion system – wind energy conversion system.

Unit - V

Energy storage: requirements and methods – storage of thermal energy – storage of mechanical energy – storage of electrical energy – storage of chemical energy – storage of nuclear energy.

Reference Books

1. Culp, A.W., Principles of energy conversion, Tata McGraw Hill, 2000
2. Messerle, Hugo K., Magnetohydrodynamic Electric Power Generation, John Wiley & Sons, 1995.
3. Linden, D., Handbook of Batteries and Fuel Cells, McGraw Hill Book Co., 1984.
4. Angrist, S. W., Direct Energy Conversion, Allyn and Bacon, Boston, 1982.
5. Green, M. A., Solar Cells, Prentice Hall Inc., Englewood Cliffs, 1982.
6. Appleby, A. J., Fuel Cell Hand Book, Van Nostrand Reinhold Co., New York, 1989.

7. Considine, D.M., Energy technology handbook, McGraw Hill, 1977
8. Glasstone, S., and Sessouske, A., Nuclear reactor engineering, Van Nostrand Reinhold, 1963
9. Russell, C.R., Elements of energy conversions, Pergamen press, 1967

ME 903 OPTIMIZATION TECHNIQUES

Unit - I

Mathematical concept of maximization and minimization – Optimal problem formulation: design variables, constraints, objective functions. Single variable optimization: Boundary phase method – Fibonacci search method – Golden section search method – Newton-Raphson method.

Unit - II

Multivariable optimization: Simplex search method – Powell's conjugate direction method – Conjugate gradient method – Variable-metric method.

Unit - III

Constrained optimization: Kuhn-Trucker conditions – Penalty function method – Frank-Wolfe method – Generalized reduced gradient method – Generalized projection method.

Unit - IV

Integer programming: Penalty function method – Branch-and-bound method – Geometric programming – Dynamic programming.

Unit - V

Genetic algorithms (GAs): working principle – difference between GAs and traditional methods – GAs for constrained optimization – Simulated annealing – Global optimization: using steepest descent method and GA.

Reference Books

1. Deb, K., Optimization for engineering design, Prentice Hall of India, 2005
2. Rao, S.S., Optimization theory and applications, Wiley Eastern, 1984
3. Reklaitis, G.V., Ravindran, A., Ragsdell, K.M., Optimization – methods and applications, Wiley, 1983
4. Davis, L., Handbook of genetic algorithms, Van Nostrand Reinhold, 1991

ME 904 ENERGY CONSERVATION AND MANAGEMENT

Unit - I

Concept of energy conservation – Sankey diagram – thermodynamic limitations: first and second laws of thermodynamics of energy transfer – availability analysis of various thermodynamics processes/devices/cycles. Need for energy conservation in domestic, transportation, agricultural and industrial sectors – Lighting and HVAC systems – simple case studies.

Unit - II

Thermal energy conservation: combustion systems and processes – combustion efficiency – boiler performance – methodology of improving the boiler performance – steam turbine and distribution systems: energy conservation in turbines – necessity for maintenance of correct pressure, temperature and quality of steam – condensate recovery – recovery of flash steam – air and gas removal – thermal insulation.

Unit - III

Heat exchange systems – recuperative and regenerative heat exchangers – compact heat exchangers – fluidized bed heat exchange systems – heat pumps – heat pipes – heat recovery from industrial processes. heat exchange networking – pinch analysis – target setting, problem table approach, composite curves – waste heat recovery and cogeneration schemes.

Unit - IV

Energy conservation in industries - energy conservation in pumps, fans, compressed air systems, refrigeration & air conditioning systems, emergency DG sets, illumination, electrical motors – energy efficient motors and variable speed motors. Case studies for energy conservation in various industries such as cement, iron and steel, glass, fertilizer, food processing, refinery etc.

Unit - V

Concept of energy management – Energy demand and supply – Economic analysis of energy options – Duties of energy managers. Energy auditing: definition, necessity and types. Understanding energy costs – bench marking – energy performance – matching energy use to requirement – maximizing system efficiencies – optimizing the input energy requirements. Fuels and energy: supplementing and substitution – energy audit instruments – energy economics: discount rate, pay back period, internal rate of return, life cycle costing – energy conservation systems analysis for safety, health and pollution.

Reference books

1. Patrick, D. and Fardo, S. W., Energy conservation and management, Prentice-Hall Inc., 1990
2. Witte, Larry C., Industrial energy management and utilization, Hemisphere publishers, Washington, 1988
3. Reiter, S., Industrial and Commercial Heat Recovery Systems, Van Nostrand Reinhold Co., 1983
4. Wayn C. Turner, Energy management handbook, The Fairmount press, 1998
5. Chiogioji, M. H., Industrial Energy Conservation, Marcel Dekker, 1985
6. Kenney, W. F., Energy Conservation in Process Industries, Academic Press, 1983
7. O' Callaghan, P., Energy Management, McGraw Hill Book Company, 1993

8. Sirchis, J., Energy Efficiency in Industry, Elsevier Applied Science, London, 1988.
9. Gottschalk, C. M., Industrial Energy Conservation, John Wiley & Sons, 1996
10. Bisio, A. and Sharon Boots (Eds.)., Encyclopedia of Energy Technology and Environment, John Wiley & Sons, New York, 1996
11. Tyagi, A. K., Handbook of energy audits and management, TERI
12. PCRA Booklets.

ME 905 DESIGN OF THERMAL EQUIPMENT

Unit - I

Classification – parallel flow – counter flow – cross flow – multi pass – temperature distribution – over all heat transfer co-efficient – log mean temperature distribution – LMTD method – correction for LMTD – NTU method – methodology of heat exchanger calculation – fouling of heat exchanger.

Unit - II

Double pipe heat exchangers – applications and design parameters – types available. Shell and tube heat exchangers with single phase flow – design procedure – flow arrangement for increased heat recovery.

Unit - III

Types of condensers and their selection – design procedures – types of evaporators – shell and tube reboilers – types and thermal design.

Unit - IV

Compact heat exchanger – introduction - plate heat exchangers – heat transfer correlations – methods of surface area calculation - finned tube heat exchangers – application of common fin tubes – fin efficiency and temperature distribution in fin tubes – thermal rating of fin tube heat exchangers – regenerators and thermal energy storage – basic concepts and classification – calculation of regenerator thermal performance.

Unit - V

Types of cooling towers – packing region – features of natural and mechanical draft towers – thermal performance of natural and forced draft cooing towers.

Reference Books

1. Hewitt, G. F., et. al., Process Heat Transfer, CRC Press, 1994
2. Kern, D.Q., Process Heat Transfer, Mc Graw Hill Book Co., New York 1950
3. Schlunder, E.U., et al., Heat Exchanger Design Hand Book - Vols. 1-5, Hemisphere Publishing Corp., New York, 1983
4. Martin, H., Heat Exchangers, Hemisphere Publishing Corporation, 1992
5. Kakac, S., R. K. Shah, A. E. Bergles and F. Mayinger, Heat Exchangers, Hemisphere Publishing Corporation, 1983
6. Kakac, S., R. K. Shah, and A. E. Bergles Low Reynolds Number Flow Heat Exchangers, Hemisphere Publishing Corporation, 1983

ME 906 COMPUTATIONAL FLUID DYNAMICS

Unit - I

Basics of Computational Fluid Dynamics (CFD) – One dimensional computation: Finite difference methods (FDM) – Finite element method (FEM) – Finite volume method (FVM) – boundary conditions for FDM, FEM, and FVM. Governing equations: Classification of partial differential equations (PDE) – Navier-Stokes system of equations – boundary conditions.

Unit - II

Finite difference methods – Formulation – Solution methods – Incompressible viscous flows – Compressible viscous flows.

Unit - III

Finite element methods – Formulation – Finite element interpolation functions – Linear problems – Non-linear problems – Incompressible viscous flows – Compressible viscous flows – Finite volume methods through finite difference methods – Formulations of finite volume equations: Burgers' equations – Incompressible and compressible flows

Unit - IV

Grid generation – Structured grid generation: Algebraic methods – PDE mapping methods – Surface grid generation – Multiblock structured grid generation. Unstructured grid generation: Delaunay-Voronoi methods (DVM) – Advancing front methods (AFM) – Combined DVM and AFM – Three dimensional applications. Adaptive methods: Structured and unstructured adaptive methods.

Unit - V

Computing techniques: Domain decomposition methods – Multigrid methods – Parallel processing. Applications of CFD: Turbulence – combustion – acoustics – Heat transfer – Multiphase flows – Electromagnetic flows.

Reference books

1. Anderson, D. A., Tannehill, J. C. and Pletcher, R. H., Computational Fluid Mechanics and Heat Transfer, Hemisphere Publishing Corporation, New York, 1984.
2. Wendt, J. F. (Ed.), Computational Fluid Dynamics – An Introduction, Springer Verlag, 1992.
3. Zienkiewicz, O. C. and Morgan, K., Finite Element and Approximation, John Wiley & Sons, 1983.
4. Reddy, J. N., An Introduction to Finite Element Method, McGraw Hill Book Co., 1984.
5. Gunzburger, M. D., Finite Element Method for Viscous Incompressible Flows, Academic Press Inc., New York, 1989
6. Chung, T. J., Computational Fluid Dynamics, Cambridge University Press,2003
7. Hoffmann, K. A., Computational Fluid Dynamics for Engineers, Engineering Education system, Wichita, Kansas, USA, 1993

8. Muralidhar, K. and Sundararajan, T., Computational Fluid Flow and Heat Transfer, Narosa Publishing House, N. Delhi, 1995
9. Fletcher, C. A., Computational Techniques for Fluid dynamics, Vol. 1: Fundamental and general techniques, Spring-Verlag, Berlin, 1998
10. Fletcher, C. A., Computational Techniques for Fluid dynamics, Vol. 1: Specific techniques for different flow categories, Spring-Verlag, Berlin, 1998
11. Fletcher, J. H., Computational Techniques for Fluid dynamics, Spring-Verlag, Berlin, 1999

ME 907 COMPUTATIONAL TECHNIQUES LABORATORY

(Programs are to be done in FORTRAN/ C)

1. Solution to linear algebraic equations using Gauss-Seidel method
2. Solution to linear algebraic equations using Conjugate Gradient method
3. Solution to linear algebraic equations using GMRES method
4. Solution to linear algebraic equations using LU decomposition method
5. Solution to nonlinear algebraic equations using Newton method
6. Determining Eigen value and Eigen vector for a system of equations
7. Finding roots of an equation using Newton-Raphson method
8. Solution to ODEs using Runge-Kutta method
9. Solution to ODEs through Finite Element method
10. Solution to Poisson's equation with Dirichlet and Convective boundary conditions
11. Solution to 2D transient conduction equation using implicit method
12. Solution to one dimensional wave equation
13. Solution to 2D problem using Fluent

ME 908 ENERGY ENGINEERING LABORATORY

1. Determination of heating/cooling load for the given space to be air-conditioned.
2. Performance test on Air Conditioning/Refrigeration system.
3. Aerodynamic study on Aerofoil and Cylinder (Pressure and Velocity distribution)
4. Energy balance test on given Steam Boiler.
5. Energy balance test on given Petrol engine.
6. Energy balance test on given Diesel engine.
7. Fuel and flue gas analysis using Gas – Chromo graph.
8. Determination of Calorific value of solid/liquid fuel using Bomb Calorimeter.
9. Determination of Calorific value of gaseous fuel using Junkers Gas Calorimeter.
10. Solar radiation – measurement and analysis.
11. Proximate analysis of solid fuel.
12. Ultimate analysis of solid fuel.
13. Pressure Time Diagram using Pressure Transducer and Charge Amplifier of a SI Engine.
14. Emission Testing using Combustion Gas Analyser.

ME 921 ADVANCED FLUID MECHANICS

Unit - I

Kinematics of fluid flow - introduction – regimes of fluid mechanics - Lagrangian and Eulerian approach - revision of concepts of different types of fluids, stream lines, path lines, velocity potentials, vorticity – substantial derivative – equations of continuity – Euler's equation – Bernoulli's equations for ideal fluid flow - flow past circular cylinder with and without circulation – flow past an aerofoil.

Unit - II

Viscous flow - stress components in real fluids – stress analysis on fluid motions – Navier Stokes equation of motion – energy equation – properties of Navier Stokes equation – exact solution of Navier Stokes equation for flow between parallel plates – couette flow – flow through pipes – flow between two concentric rotating cylinders.

Unit - III

Laminar boundary layer - laminar boundary layer equation – similarity solution for steady two dimensional flow – approximate integral method – numerical solutions - boundary layer control.

Unit - IV

Turbulence - introduction to onset of turbulence – physical and mathematical description of turbulence – Reynolds equation for turbulent motion – semi empirical theories of turbulence – turbulent flow through pipes – turbulent boundary layer equations - turbulent flow with zero pressure gradient on smooth flat plate and rough flat plate.

Unit - V

Compressible flow - fundamental equation of flow of compressible viscous and inviscid fluid – plane couette flow – exact solution – steady flow through constant area pipe – laminar boundary layer equation in compressible flow – boundary layer with pressure gradient and with zero pressure gradient – application of moment integral equation to boundary layers – turbulent boundary layer equations in compressible flow – compressible turbulent flow past a flat plate.

Reference Books

1. White, F. M., Viscous Fluid Flow – 2/e, McGraw Hill Book Co., 1991.
2. Schlichting, H. and Gersten, K., Boundary Layer Theory - 8/e, Springer, 2000.
3. Yuan, S. W., Foundations in Fluid Mechanics, Prentice Hall of India Pvt. Ltd., 1988.
4. Fox, R. W. and McDonald, A. T., Intoduction to Fluid Mechanics, John Wiley & Sons, 1995.

5. Muralidhar, K. and G. Biswas, Advanced Engineering Fluid Mechanics, Narosa Publishing House, 1999.
6. Bansal, J. L., Viscous Fluid Dynamics, Oxford & IBH Publications Co., 1977.
7. Frederick, S. Sherman, Viscous Flow, McGraw Hill Book Co., 1991.
8. Binder, Advanced Fluid Mechanics – Vols. I & II , MIR Publications.
9. Kaufmann., Fluid Mechanics, McGraw Hill Book Co.

ME 922 ALTERNATIVE FUELS AND THEIR APPLICATIONS

UNIT I

Introduction – Alternative fuels – Potential solid - liquid - and gaseous fuels. – Alcohols – ethanol, methanol, M85, E85 and gashol – properties – SI engine combustion performance and emission characteristics. Alcohols for CI engine – Alcohol fumigation – Dual fuel injection – Surface ignition and spark ignition- storage, dispensing and safety – material compatibility.

UNIT II

Vegetable oils- properties – advantages and disadvantages – Biodiesel – trans-esterification - Factors affecting the process – Properties- Biodiesel blends – engine combustion, performance and emission characteristics- material compatibility , other alternative liquid fuels – benzol – acetone – diethyl ether.

UNIT III

Alternative gaseous fuels – natural gas and LPG – production – properties of natural gas and LPG – CNG conversion kits – Advantages and disadvantages of NG and LPG – comparison of gasoline and LPG – CNG and LPG fuel feed system – LPG & CNG for CI engine – methods of fuel induction engine combustion, performance and emission characteristics.

UNIT IV

Hydrogen energy – properties , production , thermo- chemical methods – Hydrogen storage – Delivery – conversion – safety – Hydrogen engines, methods of usage in SI and CI engine – Hydrogen injection system – Hydrogen induction in SI engine.

UNIT V

Biogas – properties – Biogas for running IC engine – Biogas as vehicle fuel – biogas consumption – engine performance and emission- Biomass gasification – producer gas – consumption – dual fuel operation – engine performance and emission.

Reference books.

1. Ganesan.V, Internal Combustion Engines, Tata Mc Graw Hill Publishing company Ltd, New Delhi.
2. Ramalingam K.K, Internal Combustion Engines Theory and practice, Scitech Publications (India) Pvt, Ltd
3. H.N. Gupta, Fundamentals of internal combustion engines, Prentice Hall India, 2006.
4. Biogas System Principles and application , Mittal K.M., New Age International (P) Ltd, Publishers, 1996
5. Richard L.Bechtold, Alternative fuels guide book SAE International, Wattendale, 1997.

ME 923 BIO-ENERGY AND CONVERSION SYSTEMS

Unit - I

Biomass resources and biomass properties – biomass – definition – classification – availability – estimation of availability, consumption and surplus biomass – energy plantations. Proximate analysis, Ultimate analysis, thermo gravimetric analysis and summative analysis of biomass – briquetting.

Unit - II

Biomass pyrolysis – pyrolysis – types, slow fast – manufacture of charcoal, methods, yields and application – manufacture of pyrolytic oils and gases, yields and applications.

Unit - III

Biomass gasification – gasifiers – fixed bed system – downdraft and updraft gasifiers – fluidized bed gasifiers – design, construction and operation – gasifier burner arrangement for thermal heating – gasifier engine arrangement and electrical power – equilibrium and kinetic consideration in gasifier operation.

Unit - IV

Biomass combustion – biomass stoves – improved chullahs, types, some exotic designs – fixed bed combustors – types, inclined grate combustors – fluidized bed combustors – design, construction and operation and operation of all the above biomass combustors.

Unit - V

Biological conversion of biomass – methods – methanol, ethanol production – fermentation – anaerobic digestion digestion – biogas plants – types, of digesters, some exotic designs, factors affecting biogas generation – biogas technology for cooling, lighting and shaft power production.

Reference books

1. Desai, Ashok V., Non Conventional Energy, Wiley Eastern Ltd., 1990.
2. Khandelwal, K. C. and Mahdi, S. S., Biogas Technology - A Practical Hand Book - Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Challal, D. S., Food, Feed and Fuel from Biomass, IBH Publishing Co. Pvt. Ltd., 1991.
4. C. Y. WereKo-Brobby and E. B. Hagan, Biomass Conversion and Technology, John Wiley & Sons, 1996.

ME 924 CO-GENERATION AND ITS APPLICATIONS

Unit - I

Concept of Cogeneration – review on Thermodynamics of conventional power producing plants. Selecting cogeneration technologies.

Unit - II

Thermodynamics of Cogeneration power plants – performance criteria and effect of irreversibility.

Unit - III

Comparative thermodynamic performance of cogeneration plants – performance of cogeneration plants – Numerical examples – calculations of typical heat to power ratios and performance parameters.

Unit - IV

Design of Cogeneration plant for varying plant heat to power ratio – fuel savings from installation of cogeneration plant.

Unit - V

Economic assessment of Cogeneration schemes. Applications of cogeneration technology to various process plants.

Reference books

1. Horlock, J. H., Cogeneration Combined Heat and Power – Thermodynamics and Performance, Pergamon Press, 1986.
2. David Hu, S., Cogeneration, Reston Publishing Co., USA, 1985.
3. Sirchis, J., Combined Production of Heat and Power, Elservier Applied Science, 1990.
4. Robert Noyes, Cogeneration of Steam and Electric Power, Noyes Data Corporation, 1986.
5. Spiewak, S. A., Cogeneration, Fairmont Press Inc., 1991.
6. Kehlhofer, R., Combined Cycle Gas and Steam Turbine Power Plants, The Fairmont Press Inc., 1991.

ME 925 CRYOGENIC ENGINEERING

Unit - I

Introduction to low temperature engineering – cryogenics – principle of cryogenics – methods of production of low temperature.

Unit - II

Cryogenic fluids – superconductivity and its applications – properties of cryogenic fluids – super fluidity – selection of cryogenic fluids.

Unit - III

Cryogenic systems – Claude system – Linde Hampson system – Heylandt system – Stirling cryocooler – Gifford McMahon cryocooler – thermodynamic analysis of above systems.

Unit - IV

Instrumentation in cryogenics – temperature, pressure, flow, level measurements – cryo probes – cryostats – medical instrumentation.

Unit - V

Application of cryogenics – thermal, electrical and magnetic properties of metals, alloys and non-metals at cryogenic temperature – cryogenics for industry – food preservation – medicine – space.

Reference Books

1. Barron, Randel F., Cryogenic Systems, Oxford University Press, 1985.
2. Dinnerhaos, Q. D., Cryogenic Engineering, McGraw Hill Book Co., 1987.
3. Klaus D. Timmerhaus and Thomas M. Flynn, Cryogenic Process Engineering, Plenum Press, 1989.
4. Hasdden, G. G., Cryogenic Fundamental, Academic Press, 1971.
5. Martia Donabedian, Survey of Cryogenic Cooling Techniques.

ME 926 DESIGN OF EXPERIMENTS

Unit – I

Total Quality Management – Quality Function Development – Product and Process Optimization – Process Capability – Basics of DOE

Unit – II

Need for planned experimentation – steps in experimentation – comparison of Design of Experiments – loss function – Response Factors – Levels - Treatment combination – Effect of a factor – Experimental error – Data Analysis

Unit – III

Experimental Design – Factorial Experiments – Fractional Factorial Experiments – Taguchi's Method – Orthogonal array Design and Development – Linear Graph – interaction effect – Analysis of Variance.

Unit – IV

Optimization of Process parameter – Optimization strategy – Selection and identification of parameters – Response Graph Analysis – Signal to noise ratio analysis – Gray relational analysis

Unit – V

Optimization of cost and quality – Artificial Neural Network – Genetic Algorithms – Particle Swam optimization – Simulated Annealing Algorithm – Ant Colony Algorithm – Fuzzy logic approach

Reference Books

1. Douglus C Montgomery, Design and Analysis of Experiments, John Wiley & Sons, 1984.
2. Charles R Hicks, Holt, Rinchort and Winston, Fundamental concepts in design of experiments, 1984.
3. Phadke, M S, Quality Engineering using robust design, Prentice Hall, 1989
4. Ross J Philip, Taguchi Techniques for quality engineering, McGraw Hill, 1989
5. Genichi Taguchi, System of Experimental Design, UNIPUB, Karus International Publication, 1987
6. Deb, K., Optimization for engineering design, Prentice Hall of India, 2005

ME 927 DIRECT ENERGY CONVERSION

Unit - I

Energy conversion process – indirect and direct energy conversion – preview of semiconductor physics – basic ideas of quantum physics – fermi energy – band diagram – intrinsic and extrinsic semiconductors – p-n junction – introduction to irreversible thermodynamics.

Unit - II

Thermoelectric converters – thermoelectric effects – analysis of thermoelectric generators and coolers – thermionic conversion – thermionic effects – analysis of thermionic converters – ferro electric conversion.

Unit - III

Photovoltaic conversion – optical effects of p-n junction – design and analysis of PV cells – PV cell fabrication – system design.

Unit - IV

Magneto hydrodynamic conversion – introduction – MHD plasmas – analysis of MHD generators – MHD power applications.

Unit - V

Batteries – basic concepts – electrochemical principles and reactions – selection and application of batteries – fuel cells – general characteristics – low power fuel cell systems – fuel cell power plants.

Reference Books

1. Messerle, Hugo K., Magnetohydrodynamic Electric Power Generation, John Wiley & Sons, 1995.
2. Linden, D., Handbook of Batteries and Fuel Cells, McGraw Hill Book Co., 1984.
3. Angrist, S. W., Direct Energy Conversion, Allyn and Bacon, Boston, 1982.
4. Green, M. A., Solar Cells, Prentice Hall Inc., Englewood Cliffs, 1982.
5. Culp, Archie W., Principles of Energy Conversion, McGraw Hill Book Co., 1991.
6. Appleby, A. J., Fuel Cell Hand Book, Van Nostrand Reinhold Co., New York,1989.

ME 928 ENERGY CONVERSION AND ENVIRONMENTAL POLLUTION

Unit - I

Environmental aspects of energy utilization, energy market, sources of world energy, exhaustible and inexhaustible sources.

Unit - II

Principle fuels for energy conversion, synthetic and other fuels, energy utilization, reserve and economics.

Unit - III

Environmental considerations, types of air pollution, effects of air pollution on men and on environment.

Unit - IV

Formation of air pollutants from combustion of fossil fuels and parameters controlling their formation, pollution from automobiles and its control, pollution by industrial and municipal wastes and their treatment.

Unit - V

Pollution from thermal power plants and nuclear power plants sources and control methods and instrumentation for pollution control. Water pollution from tanneries, other industries, and their control.

References Books

1. Chigier, N. A., Energy, Combustion and Environment, McGraw Hill Book Co., 1981.
2. Sharma, S. P., et al., Fuels and Combustion, Tata McGraw Hill Publishing Co. Ltd., 1984.
3. Bruce Schwoegler and Michael McClintock, Weather and Energy, McGraw Hill Book Co., 1981.
4. Bisio, A. and Sharon Boots (Eds.), Encyclopedia of Energy Technology and Environment, John Wiley & Sons, New York, 1996.

ME 929 ENERGY MANAGEMENT IN BUILDINGS

Unit - I

Overview of the significance of energy use and energy processes in building, indoor activities and environmental control, internal and external factors on energy use and the attributes of the factors, characteristics of energy use and its management, macro aspect of energy use in dwellings and its implications.

Unit - II

Indoor environmental requirement and management, thermal comfort, ventilation and air quality, air-conditioning requirement, visual perception, illumination requirement, auditory requirement.

Unit - III

Climate, solar radiation and their influences, the sun-earth relationship and the energy balance on the earth's surface, climate, wind, solar radiation, and temperature, sun shading and solar radiation on surfaces, energy impact on the shape and orientation of buildings.

Unit - IV

End-use, energy utilization and requirements, lighting and day lighting, end-use energy requirements, status of energy use in buildings, estimation of energy use in a building. Heat gain and thermal performance of building envelope, steady and non steady heat transfer through the glazed window and the wall, standards for thermal performance of building envelope, evaluation of the overall thermal transfer.

Unit - V

Energy management options, energy audit and energy targeting, technological options for energy management.

Reference Books

1. J. Krieder and A. Rabl, Heating and Cooling of Buildings - Design for Efficiency, McGraw Hill, 1994.
2. S.M. Guinnes and Reynolds, Mechanical and Electrical Equipment for Buildings, Wiley, 1989.
3. A. Shaw, Energy Design for Architects, AEE Energy Books, 1991.
4. ASHRAE, Handbook of Fundamentals, Atlanta, 1997.
5. Donald W. Abrams, Low Energy Cooling – A Guide to the Practical Application of Passive Cooling and Cooling Energy Conservation Measures, Van Nostrand Reinhold Co., New York, 1986.

ME 930 FLUIDIZED BED TECHNOLOGY

Unit - I

Introduction – hydrodynamics – phenomenon of fluidization – regimes of fluidization – range of behavior of gas fluidized beds – principle components of fluidized beds – minimum fluidizing velocity and temperature and pressure effects – fluid dynamics of circulating fluidized beds.

Unit - II

Fluidized bed heat transfer - heat transfer mechanisms in bubbling fluidized and circulating fluidized beds – heat transfer at elevated temperatures – heat transfer in multiphase flows.

Unit - III

Combustion in fluidized beds – general considerations of fluidized bed combustor – coal science consideration – combustion models – emissions.

Unit - IV

Design of fluidized bed boilers – stoichiometric calculations – heat and mass balance – furnace design – heat absorption – design for combustion and emission performance.

Unit - V

Fluidized bed combustion boilers for power generation – atmospheric – pressurized fluidized bed combustion – thermodynamic cycles – effect of pressure on fluidization and combustion rate – performance characteristics – pressurized fluidized bed gasification.

References Books

1. Basu, P. and Fraser, S. A., Circulating Fluidized Bed Boilers – Design and Operations, Butterworth Heinemann, Boston, 1991.
2. Molerus, O. and Wirth, K. E., Heat Transfer in Fluidized Beds, London, 1997.
3. Kunii, D and Levenspiel, O., Fluidization Engineering, John Wiley & Sons Inc., New York, 1969.
4. Davidson, J. F. and Harrison, D. (Eds.), Fluidization, Academic Press, London, 1971.
5. Geldard, D. (Ed.), Gas Fluidization, John Wiley & Sons, New York, 1983.
6. Howard, J. R., Fluidized Bed Technology – Principles and Application, Adam Hilger, Bristol, 1989.
7. Davidson, J. F. and Keairns, D. L. (Eds.), Fluidization, Academic Press, London, 1978.

ME 931 MODELLING AND SIMULATION OF ENERGY SYSTEMS

Unit – I

Mathematical modeling – interpolations – polynomial and Lagrangian – solution of simultaneous linear equations – curve fitting – regressions analysis – solution of transcendental equations – modeling of thermal equipment – heat exchangers – turbo machines.

Unit – II

System simulation – classes of simulation – information flow diagram. Methods used in simulation – successive substitution – Newton Raphson methods. Examples of energy systems – gas turbines – refrigeration – pumps.

Unit – III

Optimization – objectives and constraints – problem formulation – unconstrained optimization – constrained optimization using Lagrange multiplier equations – Kuhn-Tucker conditions.

Unit – IV

Optimization using search methods – univariate search methods – constrained optimization using penalty functions – conjugate gradient method. Introduction to genetic algorithms and simulated annealing.

Unit – V

Steady state simulation of large systems – convergence and divergence in successive substitution – partial substitution in successive substitution – characteristics of Newton-Raphson method – quasi Newton method – application in simulation of energy systems. Application of optimization techniques to energy systems.

Reference Books

1. Stoecker, W. F., Design of Thermal Systems, McGraw Hill Book Co., 1989.
2. Bejan, A., G. Tsatsaronis and M. Moran, Thermal Design and Optimization, John Wiley & Sons, 1996.
3. Rao, S. S., Optimization Theory and Applications, Wiley Eastern Ltd., 1990.
4. Hodge, B. K., Analysis and Design of Energy Systems, Prentice Hall Inc., 1990.
5. Press, W. H., et al., Numerical Recipes in Fortran – 2/e, Cambridge University Press, 1996.

ME 932 NUCLEAR POWER ENGINEERING

Unit - I

Radioactivity – nuclear reactions – binding energy – neutron interaction – cross sections – fission – power from fission – fission chain reactions – criticality – conversion and breeding – nuclear fuel performance.

Unit - II

Nuclear power reactors – nuclear fuel cycles – fuel enrichment – fuel assembly – fuel reprocessing – decommissioning of power plants – radioactive waste disposal and its management.

Unit - III

Neutron flux – diffusion theory applications – ficks law – solution to diffusion equation for point source – plannar source and bare slab – diffusion length – energy loss in scattering collisions – moderators.

Unit - IV

One group reactor equation – one group criticality equation – thermal reactors – criticality calculations – homogeneous and heterogeneous reactors – reactor kinetics and safety – prompt neutron life time – reactor with and without delayed neutrons – prompt criticality – control rods – principles of nuclear rector safety.

Unit - V

Heat generation in reactors – thermal constraints – heat transfer to coolants – thermal design of reactor.

Reference Books

1. Lamarsh, J. R., Introducation to Nuclear Engineering, Addison-Wesley, New York, 1983.
2. Marshall, W., Nuclear Power Technology - Vol. I, II & III, Clarendon Press, Oxford, 1985.
3. Samuel Glasstone, Principle of Nuclear Reactor Engineering, Van Nostrand Reinhold Co., New York, 1963.
4. Culp, Archie W., Principles of Energy Conversion, McGraw Hill Book Co., 1991.

ME 933 UTILISATION OF SOLAR ENERGY

Unit - I

Solar energy collection with flat plate collectors – solar radiation – estimation and measurement. Flat plate collectors – liquid flat plate collectors – selective surfaces cover plates – thermal analysis of collector – materials for components. Air heating collectors – construction and analysis.

Unit - II

Concentrating collectors – compound parabolic concentrators. Central receiver – heliostat systems. Solar energy storage – water storage – packed bed storage – phase change storage.

Unit - III

Solar thermal systems – solar heating systems – performance and analysis. Solar cooling systems – performance and analysis – Heat pump.

Unit - IV

Solar cells – photovoltaic principle – materials for photovoltaic cells. Design and fabrication of photovoltaic cells – performance analysis of photovoltaic cells – thermoelectric generator solar cells – photochemical solar cells – solar cells in terrestrial and space applications.

Unit - V

Solar power systems – electrical power generation. Solar thermal power plants – central receiver power plants – Solar ponds. Solar energy process economics.

Reference Books

1. Duffie, J. A. and Beckmann, W., Solar Thermal Process, John Wiley & Sons, 1980.
2. Mani, A. and Rangarajan, S., Solar Radiation over India, Allied Publishers Pvt. Ltd., 1982.
3. Bansal, N. K., Manfred Kleeman and Michael Meliss, Renewable Energy Sources and Conversion Technology, Tata McGraw Hill Publishing Co. Ltd., 1990.
4. Jiu Sheng Hsieh, Solar Energy Engineering, Prentice Hall Inc., 1991.
5. Sukhatme, S. P., Solar Energy, Tata McGraw Hill Publishing Co. Ltd., 1984.

ME 934 UTILIZATION OF WIND AND HYDROGEN ENERGIES

Unit – I Wind Energy Conversion

Wind energy: Statistics – measurements and presentation – Principles of wind energy conversion – Classification of wind energy conversion systems – Power, speed and torque characteristics – Economics of wind energy utilization – Wind energy scenario in India – Wind energy applications: stand-alone system – grid and hybrid connected systems.

Unit – II Theory of Wind Energy Conversion System

Wind turbine aerodynamics: Basics of aerodynamics – Momentum theories - Aero-foils and their characteristics – Horizontal axis wind turbine (HAWT): Blade element theory – Prandtl's lifting line theory – Aerodynamics of vertical axis wind turbine (VAWT) – Wind turbine loads: Aerodynamic loads in steady operations – wind turbulence – yawed operation – tower shadow.

Unit – III Design of Wind Energy Converters

Selection criteria: Site – Rotor – Annual energy output – Design of HAWT and VAWT: Rotor design considerations – Number of blades – Blade profiles – Teetering – Coning – Power regulations – Yaw system – Tower – Synchronous and asynchronous generators and loads – Integration of wind energy converters to electrical networks: inverters – control systems –Testing of wind energy conversion systems.

Unit – IV Hydrogen Energy

Hydrogen as an energy source – Properties of hydrogen – Combustion methods and devices – Economics of hydrogen energy – Production of hydrogen: natural resource – biological source - electrolytic process – thermal decomposition – biochemical method – photochemical method – photo-catalytic method.

Unit – V Hydrogen Energy Storage, Transportation and Applications

Selection of storage: Gaseous, liquid – Method of storage: Gaseous hydrogen, cryogenic method, metal hydrides, carbon nano-tubes, sea as a source of deuterium – Transportation: methods of transport – cryo-cooled systems – Fuel cells – Applications of hydrogen energy in land and space vehicles – Hydrogen power technologies.

Reference Books

1. Freris, L. L., Wind Energy Conversion Systems, Prentice Hall, 1990
2. Spera, d. a., Wind Turbine Technology: Fundamental concepts of wind turbine engineering, ASME Press
3. Johnson, G. L., Wind Energy Systems, Prentice Hall, 1985
4. Walker, J. F., Wind Energy Technology, John Wiley, 1997
5. Veziroglu, T. N. and Barbir, F., Hydrogen Energy Technologies, UNIDO Emerging Technologies Series, UNIDO, Vienna, 1998

6. Jamasb, T., Pollitt, M. G. and Nuttall, W. J., Future Electricity Technologies and Systems, Cambridge University Press, 2006

ME 961 Directed study

Each candidate is required to make a study on a relevant topic connected with the field of specialization. The topic shall be chosen in consultation with the concerned Faculty Guide and Head of the Department. It would be such as to develop investigative and creative ability of the candidate. A presentation shall be given after a thorough investigation of the literature and other data relevant to the topic

ME 909 MAJOR PROJECT (PHASE – I)

The project work is to acquaint the student in the analysis of problems posed to him, in the method of conducting a detailed literature survey and reviewing the state of art in the area of the problem. If the major project (Phase–I) which is not purely theoretical, student is also expected to design, conduct and develop skills of experimental work, in some of them and to analyse the results obtained. An Internal Examiner will examine the project report written at a viva-voce.

ME 910 MAJOR PROJECT (PHASE – II)

The student will take up the Major Project (Phase–II) in the fourth semester. This is aimed at exposing the students to analyze independently his project work. The work may be purely analytical or completely experimental or combination of both. In few cases, the project can also involve a sophisticated design work. The major project report is expected to show clarity of thought and expression, critical appreciation of the existing literature and analytical and/or experimental or design skill. The dissertation work should be of relevant nature for the current and the future needs of the country. The dissertation report will be examined at the time of viva-voce.