M.Tech

THERMAL POWER ENGINEERING

SYLLABUS FOR CREDIT BASED CURRICULUM

(For Students Admitted in 2011-12)

DEPARTMENT OF MECHANICAL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY

TIRUCHIRAPPALLI – 620 015.

INDIA

JUNE 2011

NATIONAL INSTITUTE OF TECHNOLOGY - TIRUCHIRAPPALLI
DEPARTMENT OF MECHANICAL ENGINEERING

M.Tech. THERMAL POWER ENGINEERING

The total credits required for completing the M.Tech. Programme in Mechanical Engineering is 61

CODE	COURSE OF STUDY	L	T	P	C
	SEMESTER I				
MA 609	Mathematical Methods	3	0	0	3
ME 601	Fuels, Combustion and Emission Control	3	0	0	3
ME 603	Advanced Fluid Mechanics	3	0	0	3
ME 605	Advanced Heat Transfer	3	0	0	3
ME 607	Analysis and Design of Pressure Vessels	3	0	0	3
	Elective I	3	0	0	3
	Total	**18**	**0**	**0**	**18**
	SEMESTER II				
ME 602	Fluid Mechanics of Turbomachines	3	0	0	3
ME 604	Heat Transfer Equipment Design	3	0	0	3
ME 606	Computational Fluid Dynamics	3	0	0	3
ME 608	Computation Fluid Dynamics Laboratory	0	0	3	1
	Elective II	3	0	0	3
	Elective III	3	0	0	3
	Elective IV	3	0	0	3
	Total	**18**	**0**	**3**	**19**
	SEMESTER III				
ME 747	Project Work – Phase I	0	0	0	**12**
	SEMESTER IV				
ME 748	Project Work – Phase II	0	0	0	**12**
	Total Credit				**61**

LIST OF ELECTIVES

ME 631	Energy Conservation, Management, and Audit
ME 632	Boiler Auxiliaries and Performance Evaluation
ME 633	Tribology
ME 634	Finite Element Method in Heat Transfer Analysis
ME 635	Analysis of Thermal Power Cycles
ME 636	Safety in Thermal and Nuclear Power Plants
ME 637	Installation, Testing and Operation of Boilers
ME 638	Instrumentation
ME 639	Boiler Production Technology
ME 640	Thermal Piping Analysis and Design
ME 641	Design and Optimisation of Thermal Energy Systems**.**
ME 642	Cogeneration and waste Heat Recovery Systems.
ME 643	Advanced IC Engines
ME 671	Environmental Pollution Control

SEMESTER I

MA 609 MATHEMATICAL METHODS (3 – 0 – 0) 3

Calculus of variations - Euler's equation - Variational problems in parametric form - Natural boundary condition – Conditional Extremum - Isoperimetric problems.

Direct methods in Variational Problems - Euler's finite difference method - Rayleigh -Ritz method - Galerkin's method - Kantorovich's method.

Integral equations - Conversion of BVP to integral equations using Green's Function - Fredholm equation with separable kernels – Solution of Fredholm and Volterra equations by the method of Successive approximations.

Finite difference scheme for elliptic, parabolic, and hyperbolic partial differential equations.

Introduction to Finite Element Method - Rules for forming interpolation functions - Shape functions Application to fluid flow and heat transfer problems.

References:

1. DESAI, C.S., and ABEL, J. P., Introduction to Finite Element Method, Van Nostrand Reinhold.
2. ELSEGOLTS, L., Differential Equations and the Calculus of Variations, Mir Publishers.
3. GREWAL, B.S. , Higher Engineering Mathematics, Khanna Publishers.
4. HILDEBRAND, P.B., Method of Applied Mathematics, Prentice Hall.
5. VENKATARAMAN, M. K., Higher Mathematics for Engineering and Science, National Publishing Company.

ME 601 FUELS, COMBUSTION, AND EMISSION CONTROL (3 – 0 – 0) 3

Types of fuels and their properties - Coal characterization - Combustion chemistry - Stoichiometry Heat of reaction - Calorific value - Adiabatic flame temperature - Equilibrium - Mass transfer.

Chemical kinetics - Important chemical mechanisms - Simplified conservation equations for reacting flows - Laminar premixed flames - Simplified analysis.

Factors influencing flame velocity and thickness flame stabilization - Diffusion flames - Introduction to turbulent flames.

FBC - Different types of FBCs - Models for droplet and Carbon particle combustion.

Emissions - Emission index - Corrected concentrations - Control of emissions for premixed and non-premixed combustion.

References:

1. Turns, S.R., *An Introduction to Combustion - Concepts and Applications, 2nd* ed., McGraw-Hill, 2000.
2. Sharma, S.P. and Mohan, C., *Fuels and Combustion,* Tata McGraw-Hill, 1987.
3. Sarkar. S., *Fuels and Combustion,* Orient Longman, 2005.

ME 603 ADVANCED FLUID MECHANICS (3 – 0 – 0) 3

Review of Basic concepts- Reynold's transport theorem, Fluid kinematics - Physical conservation laws - Integral and differential formulations.

Navier-Stokes and energy equations - Dimensionless forms and dimensionless numbers - Solution of Navier-Stokes equations.

Two-dimensional Potential flows - Different types of flow patterns. Boundary layer theory - Blasius solution - Momentum integral approach.

Turbulent flows - Reynolds equation - Prandtl and von Karman hypothesis- Universal velocity profile near a wall- flow through pipes

Boundary layer concept- Boundary layer thickness- prandtl's equations-blassius solution-skin friction coefficient.

References:

1. Currie, LG., *Fundamental Mechanics of Fluids, 3rd* ed., CRC Press, 2002.
2. White, P.M., *Viscous Fluid Flow, 2nd* ed., McGraw-Hill, 1991.
3. Ockendon, H. and Ockendon, J., *Viscous Flow,* Cambridge Uni. Press, 1995.

ME 605 ADVANCED HEAT TRANSFER (3 – 0 – 0) 3

Transient heat conduction - Exact solution - Use of Heisler and Grober chart-Integrated method.

Extended surfaces - Steady state analysis and optimization-Radial fins of rectangular and hyperbolic profiles- longitudinal fin of rectangular profile radiating to free space.

Thermal boundary layers - Momentum and energy equations -Internal and external flows- Forced convection over cylinders, spheres and bank of tubes.

Heat transfer with phase change – condensation and boiling heat transfer- Heat transfer in condensation, Effect of non-condensable gases in condensing equipments. Flow boiling correlations.

Radiative exchange in furnaces-Radiation characteristics of particle systems, Thermal radiation of a luminous fuel oil and gas- Soot flame- overall heat transfer in furnaces.

References:

1. Ozisik, M.N., *Heat Tran5fer - A Basic Approach,* McGraw-Hill, 1987.
2. Incropera, P.P. and Dewitt, D.P., *Fundamentals of Heat and Mass Transfer, 5th* ed., John Wiley, 2002.
3. Kakac, S. and Yener, Y., *Convective Heat Transfer,* CRC Press, 1995.
4. Kraus, A.D., Aziz, A., and Welty, J., *Extended Surface Heat Tran5fer,* John Wiley, 2001.

ME 607 ANALYSIS AND DESIGN OF PRESSURE VESSELS (3 – 0 – 0) 3

Establishment of design conditions – Fracture Mechanics – Heads, Basic shell thickness - Reinforcement of openings – Special components like flange, tube plate, supports.

Cylindrical shells – Thick cylinders- Lame's solution - Theories of breakdown of elastic action – Unrestrained solution – Lateral loading – General loading. Axisymmetric loading - Membrane solutions - Edge bending solutions - Flexibility matrix.

Application of general analysis – Flat closure plates –conical heads and reducers – hemispherical and torispherical, ellipsoidal heads.

Development of cracks - Fracture mechanics - Corrosion - Selection of working stress for ductile and brittle materials.

Finite element analysis for high pressure and high temperature components.

References:

1. Bickell, M.B. and Ruiz, c., *Pressure Vessel Design and Analysis,* MacMillan, London, 1967.
2. Den Hartog, J.P., *Advanced Strength of Materials,* McGraw-Hill, 1949.
3. Timoshenko, S., *Strength of Materials,* Van Nostrand, 1986.

SEMESTER II

ME 602 FLUID MECHANICS OF TURBOMACHINES (3 – 0 – 0) 3

Introduction and cascades - Two-dimensional cascades - Analysis of cascade forces – Energy losses – Cascade correlation – Off design performance.

Power generating machine I - Axial flow turbines- Stage losses and efficiency – Soderberg's correlation – Turbine flow characteristics

Power absorbing machine I - Axial flow compressors, pumps, and fans – Three dimensional flow in axial turbo machines – theory of radial equilibrium – actuator disc approach – Secondary flows

Power absorbing machine II - Centrifugal pumps, fans, and compressors – slip factor – optimum design of centrifugal compressor inlet choking in a compressor stage.

Power generating machine II - Radial flow turbines, Loss coefficients – off design operating condition – clearance and windage losses 90 deg IFR turbines.

References:

1. Dixon, S.L., *Fluid Mechanics and Thermodynamics of Turbomachinery, 5th* ed., Butterworths Heinemann, 2005.
2. Csanady, G.T., *Theory of Turbomachines,* McGraw Hill, 1964.
3. Prithvi Raj, D. and Gopalakrishnan, G., *A Treatise on Turbomachines,* Scitech Publication, 2003.

ME 604 HEAT TRANSFER EQUIPMENT DESIGN (3 – 0 – 0) 3

Classification of heat transfer equipment - Design of shell and tube heat exchanger - Finned surface heat exchanger –Heat exchangers for special services – Fired heaters

Plate and spiral plate heat exchanger – plate heat exchanger for Dairy industry – Heat Pipes

Thermal design of heat exchange equipments such as Air pre-heaters , Economizer – Super heater and condensers.

Selection of compact heat exchangers.

Analysis and design of cooling towers.

References:

1. Ganapathy, v., *Applied Heat Transfer,* Pennwell Books, 1982.
2. Kays, W.M. and London, A.L., *Compact Heat Exchangers,* McGraw-Hill, 1998.
3. Dunn, P. and Reay, D.A., *Heat Pipes,* Pergamon, 1994.
4. Kakac, S. and Liu, H., *Heat Exchangers,* CRC Press, 2002.

ME 606 COMPUTATIONAL FLUID DYNAMICS (3 – 0 – 0) 3

Classification of partial differential equations - Discretization methods - finite difference and finite volume formulations –classificatrion of PDES.

Numerical solution of elliptical equations - Linear system of algebraic equations – Iterative solution of system of linear equation.

Model Equations – Wave equations - Numerical solution of parabolic equations - Stability analysis – Advanced shock capturing schemes.

Solutions of convection - Diffusion equation – Conservative and non-conservative schemes – concept of artificial viscosity and Numerical Diffusion.

Navier-Stokes equations and algorithms; Basics of grid generation- Numerical solution of hyperbolic equations - Burgers equation generation.

References:

1. Tannehill, J.c., Anderson, D.A., and Pletcher, R.H., *Computational Fluid Mechanics and Heat Tran5fer, 2nd* ed., Taylor & Francis, 1997.
2. Hoffmann, K.A. and Chiang, S.T., *Computational Fluid Dynamics for Engineers,* Engineering Education Systems, 2000.
3. Peyret, R. and Taylor, T. D., *Computational Methods for Fluid Flow,* Springer-Verlag, 1983.

ME 608 COMPUTATIONAL FLUID DYNAMICS LABORATORY (0 – 0 – 3) 1

Heat transfer & fluid flow analysis in pipes, cascades, ducts, heat exchanger, heat transfer equipment, Materials processing using CFD package.

ELECTIVES

ME 631 ENERGY CONSERVATION, MANAGEMENT, AND AUDIT (3 – 0 – 0) 3

Energy Scenario - Basics of Energy and its various forms - Energy Management and -Audit - Material and Energy Balance -Energy Action Planning-Financial Management -Project Management -Energy Monitoring and Targeting -Global Environmental Concerns

Energy Efficiency in Thermal Utilities - Fuels and Combustion-Boilers-Steam System-Furnaces - Insulation and Refractory -FBC Boilers -Cogeneration -Waste heat recovery

Energy Efficiency in Electrical Utilities-Electrical Systems-Electric Motors-Compressed Air System-HVAC and Refrigeration System-Fans and Blowers-Pumps and Pumping System-Cooling Tower-Lighting System-Diesel Generating System-Energy Efficient Technologies in Electrical Systems

Energy Performance Assessment for Equipment and Utility systems -Boilers-Furnaces-Cogeneration, Turbines (Gas, Steam)- Heat Exchangers-Electric Motors and Variable Speed Drives-Fans and Blowers-Water Pumps-Compressors

HVAC Systems-Lighting Systems-Performing Financial Analysis-Applications of Non-Conventional and Renewable Energy Sources-Waste Minimization and Resource Conservation

References:

1. *Guide book for National Certification Examination for Energy Managers and Energy Auditors,* Bureau of energy efficiencies, 2005.

ME 632 BOILER AUXILIARIES AND PERFORMANCE EVALUATION (3 – 0 – 0) 3

Boiler types – Specification – Circulating systems - Efficiency calculation - Balance diagram – Drum Internals – Desuperheaters.

Fuel and Ash handling Equipment – Mills - Specification – Selection – Operation – Maintenance.

Feed pumps – Different types, Specifications, Operation and maintenance aspects - Fans, blowers – Applications – Performance requirements, Selection, Operation and maintenance.

Dust cleaning equipment – Selection criteria – Design, operation and maintenance of electro static precipitators, Bag filters.

Soot blowers – Various types and their constructional features – Specifications – Selection – Operation and Maintenance.

References:

1. *Modern Power Station Practice,* CEGB London, Pergamon Press, 1991.
2. Eck, B., *Fans,* Pergamon Press, 1973.
3. Shields, C.D., *Boilers, Types Characteristics and Functions,* McGraw-Hill, 1961.

ME 633 TRIBOLOGY (3 – 0 – 0) 3

Introduction - Tribology in design, Tribology in industry. Lubricants- Properties- physical and chemical, Types of additives, extreme pressure lubricants. Lubrication-introduction, basic modes of lubrication

Friction - friction measurement, theory of friction. Wear: Types of wear, various factors affecting wear, measurement of wear, wear between solids and liquids, theory of wear.

Gas Lubrication. Lubrication in metal working: Rolling, Forging, Drawing and extrusion.

Solid tribological coatings and materials, – surface treatments –surface modification processes. Tribological properties of metallic and ceramic coatings.

Surface topography measurements - Electron microscope and friction and wear measurements - Use of transducers and instruments in Tribology- film thickness measurement using modern techniques – Development of test rigs for Tribology research.

References:

1. Kenneth C Ludema, *Friction, Wear, Lubrication: A text book in Tribology*, CRC press, 1996.
2. G. W. Stachowiak, A. W. Batchelor and Gwidon Stachowiak, *Engineering Tribology*, Butterworth-heinemann, 2006.

3. S. K. Basu, S.N.Sengupta & B.B.Ahuja, *Fundamentals of Tribology*, Prentice –Hall of India Pvt Ltd , New Delhi, 2005.
4. J.A. Williams, *Engineering Tribology*, Oxford Univ. Press, 1994.

ME 634 FINITE ELEMENT METHOD IN HEAT TRANSFER ANALYSIS (3 – 0 – 0) 3

Introduction, Weighted Residual Methods, Shape functions, Coordinate systems, Numerical Integration.

Modeling of Heat Conduction, Variational Formulation, Galerkin's Approach for one dimensional and two dimensional problems

One dimensional Problem solved using a single element – Linear element, Quadratic element, the use of numerical integration. A one dimensional problem solved using an assembly of elements.

Time stepping methods for Heat Transfer – Galerkin's approach in Non-linear transient heat conduction problems.

Basic Equations, Galerkin's Methods for steady Convection – Diffusion problems, Upwind Finite Elements in One Dimension, Heat Transfer in fluid flow between parallel planes, Convection on melting and solidification.

Laboratory Experiments

1. Basic problems in Heat Transfer Analysis using ANSYS
2. 1D, 2D and 3D conduction field problems
3. Convection problems
4. Heat Transfer and Fluid Flow
5. Convection on Melting and Solidification

References:

1. H. R. Thomas, K. N. Seetharamu, Ken Morgan, R. W. Lewis, "*The Finite Element Method in Heat Transfer Analysis*", John Wiley & Sons Inc, 1996.
2. Roland W. Lewis, Perumal Nithiarasu and K.N. Seetharamu, *"Fundamentals of the Finite Element Method for Heat and Fluid Flow"*, Wiley; 1 edition, 2004.
3. J.N. Reddy and D.K. Gartling, *"The Finite Element Method in Heat Transfer and Fluid Dynamics",* CRC; 2 edition, 2000.

ME 635 ANALYSIS OF THERMAL POWER CYCLES (3 – 0 – 0) 3

Steam power plant cycle - Rankine cycle - Reheat cycle - Regenerative cycle with one and more feed heaters - Types of feed heaters - Open and closed types - Steam traps types.

Cogeneration - Condensing turbines - Combined heat and power - Combined cycles - Brayton cycle Rankine cycle combinations - Binary vapour cycle.

Air standard cycles - Cycles with variable specific heat - fuel air cycle - Deviation from actual

cycle.

Brayton cycle - Open cycle gas turbine - Closed cycle gas turbine - Regeneration - Inter cooling and reheating between stages.

Refrigeration Cycles - Vapour compression cycles - Cascade system - Vapour absorption cycles - GAX Cycle.

References:

1. Culp, R., *Principles of Energy Conversion,* McGraw-Hill, 2000.
2. Nag. P.K., *Power Plant Engineering, 2nd* Tata McGraw-Hill, 2002.
3. Nag. P.K., *Engineering Thermodynamics, 3rd* ed., Tata McGraw-Hill, 2005.
4. Arora, C.P., *Refrigeration and Air Conditioning, 2nd* ed., Tata McGraw-Hill, 2004.

ME 636 SAFETY IN THERMAL AND NUCLEAR POWER PLANTS

General safety considerations to be followed in material handling - Access requirements and welding. Safety in Commissioning of Thermal Power Plant Equipment - Steam blowing safety valve floating - Commissioning of rotary equipment.

Furnace explosions and implosions - Fire and other emergencies in boiler house - Mill bay - Air preheater bay - Cable racks and transformers - Pressure and nonpressure parts - Controls and protection logics .

Hydrogen plant - Cooling water system - Chemical handling - Fuel handling systems for coal, oil and gas - Electrostatic precipitator and H.V. rectifier.

Pressure parts - underground piping - Piping with a medium such as inflammable gas or vapour - Air preheaters and fans - Burner system - Closed vessels - Turbo generators - Switch-gears and transformers.

Safety in Nuclear Power Plants - Basic concepts - Radiation hazards and control practices - Reactor design safety features - Radioactive waste disposal Atomic Energy act - Radiation protection rules.

References:

1. Sterman, L.S., “Thermal and Nuclear Power Stations”, MIR Publications, 1986.
2. El. Vakil, M.M., “Nuclear Power Technology”, McGraw Hill, 1992.
3. Loffness, R.L., “Nuclear Power Plant”, Van Nostrand, 1987.
4. Lish, K.C., “Nuclear Power Plants Systems and Equipment”, Industrial Press, New York, 1972.
5. “Modern Steam Plant Practice”, Institution of Mechanical Engineers, Birdcage, Higgin Bothams, 1989.
6. “Fossil Power Systems”, by Combustion Engineering, 1990.

ME 637 INSTALLATION TESTING AND OPERATION OF BOILERS (3 – 0 – 0) 3

Methods and procedure of installation supporting structure - Civil foundations - sequence of Erection - HSFC Bolts. Pressure parts erection and alignment. - Provision for expansion.

Mountings - Seal boxes & seal welding, Erection of ESP, Rotary APH and fans - alignment and grouting of fans. Erection of ducks and dampers - 'Cold Pull'.

Lining and Insulation - Material characteristics and selection, Arrangements of refractory/insulation in modern boilers - methods of application.

commissioning activities - Objectives - Pre commissioning checks - chemical cleaning Initial operation - Boiler turning and performance optimization.

Special commissioning checks - Preventive maintenance of boilers and auxiliaries, tube failures - causes and prevention - life estimation for very old boilers - Thermal performance tests and capacity restoration.

References:

1. "Erection of Boilers and Auxiliary Equipment", Manuals Prepared by B.H.E.L., Tiruchirappalli, 1990.

ME 638 INSTRUMENTATION (3 – 0 – 0) 3

Generalized instrumentation system – Error theory – Calibration of instruments – Range – resolution – Span – Linearity, Sensitivity- Signal conditioning systems.

Static and dynamic characteristics of instruments zero order, first order, second order instruments.

Error analysis - Uncertainty propagation – Oscilloscope for analysis of dynamic and transient events.

Principles and analysis of measurement systems used for measurement of flow, power, pressure, and temperature.

Basics of control system - Types of control – proportional control, Derivative control, Integral control, PID control-Programmable logic controllers.

References:

1. Doebelin, E.O., *Measurement Systems - Application and Design, 5th* ed., McGraw-Hill, 2004.
2. Beckwith, T.G., Buck, L., and Marangoni, R.D., *Mechanical Measurements,* Narosa Pub. House,1987.
3. Hewlett Packard, *Practical Temperature Measurements* - Application Note 290, 1995.

ME 639 BOILER PRODUCTION TECHNOLOGY (3 – 0 - 0) 3

Mechanics of metal working, Effect of temperature, stain rate and metallurgical structure on metal working. Workability, Residual stresses. Casting of Valves components, coal compartment assembly. Forging - Open die forging and closed die forging, different types of dished ends, Cold bending - Explosive and hydrodynamic forming of dished ends.

Types of rolling - rolling of bars and shapes, forces and geometrical relationship in rolling, rolling defects. Edge preparation: Beveling of tubes for headers, drums, stubs. Tube Expanders.

Welding and allied processes an overview – SMAW – GTAW, GMAW, Resistance welding, Electron beam welding, ultrasonic welding, Laser welding, Friction welding, Plasma arc welding,

Welding metallurgy – Thermal effects – heat treatment associated with welding, testing and inspection – Destructive and Non-Destructive welding. Welding Joint design – location- symbol.

Manufacture of pressure vessel components – manufacture of boiler drums, headers, structures, water walls, super heaters, mills, fans. Manufacture of heat exchangers and nuclear components.

References:

1. ASM Metals Handbook. Vol.14, "Forming and Forging", Metals Park, Ohio, USA, 1990.
2. Dieter. G.E., "Mechanical Metallurgy", McGraw-Hill Co. 1995.
3. Kurt Lange, "Hand book of Metal Forming", McGraw Hill Book Company, 1985.
4. AWS Welding Hand Books", Section 1 to VIII, American Welding Society, 1996.
5. Larry F. Jeffus., "Welding: principles and applications, 5th edition, Delmer Publishers, 2004

ME 640 THERMAL PIPING ANALYSIS AND DESIGN (3 – 0 – 0) 3

Stresses in pipes due to fluid pressure – Collapsing pressure – Thin and thick walled cylinders – Code formulae for pipe wall thickness – Losses in piping systems – Effect of curvature on resistance of bends.

Stable and unstable deformations – Plastic deformation under uniaxial stress – Tri-axial stress – Yield condition – Plastic stress - strain relationship for tri-axial stress – Failure and Plastic Instability – Creep – Brittle and ductile fracture – Fatigue.

Codes and standards – Design considerations: Loadings – Design limits, Allowable stresses and Allowable stress ranges – Stress Evaluation – Combination of Stresses: Stress Intensification and Flexibility Factors – Evaluation of Deflections and Reactions.

Introduction – Failure theories: Maximum principal stress theory and Maximum shear stress theory – stress categories – stress limits – fatigue – Classification of loads – service limits – code requirements.

Structural loading: In-plane bending moment (closing and opening), Out of plane moment – Internal and External pressure – Combined loading – Occasional loads – Creep – Fatigue –

Stress analysis – Shakedown –Limit analysis – Calculation of Collapse and Instability loads – Corrosion and Erosion Effects – Case studies using Finite Element Method.

References

1. The American Society of Mechanical Engineers, "ASME Boiler and Pressure Vessel code", New York, ASME, 2004.
2. King R.C., "Piping Handbook", 5th edition, McGraw Hill Book Company, 1973.
3. Nayyar, Mohinder L, "Piping Handbook",7th edition, McGraw Hill, 2000.
4. John F. Harvey, "Theory and Design of Pressure Vessels", CBS Publishers, 2001.
5. The M.W. Kellogg Company, Design of Piping Systems", 2nd edition, John Wiley & Sons, 1956.

Web references

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Elsevier's Science Direct URL: http://www.sciencedirect.com/
ASME Journals URL: http://scitation.aip.org/publications/myBrowsePub.jsp

ME 641 DESIGN AND OPTIMISATION OF THERMAL ENERGY SYSTEMS(3 – 0 - 0) 3

Introduction to Energy System Design - Regression analysis and Equation fitting

Modeling of thermal equipment - heat exchangers, evaporators, condensers, turbomachines, distillation equipment. Absorber, generator, GAX.

System simulation - Application of successive method and Newton Raphson Method to Energy Systems

Mathematical Representation for Optimization Problems in Energy Systems-Applications of various search methods to Energy Systems - Waste Heat Recovery System - design of energy recovery systems

Cost analysis by present worth-annual cost-Evaluating potential Investments-Forecasting Techniques-Economic Factors in Energy Systems-Examples- Genetic Algorithms – using MATLAB.

References

1. Hodge, B.K. and R.P. Taylor, *Analysis and Design of Energy Systems, 3rd Edition*, Prentice Hall, 1999.
2. Stoecker, W.F., Design of Thermal Systems, McGraw-Hill, 1989,
3. Burmeister, L.C., Elements of Thermal-Fluid System Design, Prentice Hall, 1998.
4. Jaluria, Y., Design and Optimisation of Thermal Systems, McGraw-Hill, 1998.
5. Janna, W.S., Design of Fluid Thermal Systems, PWS-Kent Publishing, 1993.

ME 642 COGENERATION AND WASTE HEAT RECOVERY SYSTEMS (3 – 0 - 0) 3

Cogeneration - Introduction - Principles of Thermodynamics - Combined Cycles-Topping - Bottoming - Organic Rankine Cycles - Advantages of Cogeneration Technology

Cogeneration Application. Sizing of waste heat boilers - Performance calculations, Part load characteristics - selection of Cogeneration Technologies – Financial considerations.

Waste heat recovery - Introduction - Principles of Thermodynamics and Second Law - sources of Waste Heat recovery - Power Plant.

Waste heat recovery systems - Design Considerations - fluidized bed heat exchangers - heat pipe exchangers - heat pumps -thermic fluid heaters - selection of waste heat recovery technologies

Environmental considerations for cogeneration and waste heat recovery - Pollution.

References:

1. Charles H.Butler, Cogeneration, McGraw Hill Book Co., 1984.
2. Horlock JH, Cogeneration - Heat and Power, Thermodynamics and Economics, Oxford,1987.
3. Institute of Fuel, London, Waste Heat Recovery, Chapman & Hall Publishers, London, 1963.
4. Sengupta Subrata, Lee SS EDS, Waste Heat Utilization and Management, Hemisphere, Washington, 1983.
5. De Nevers, Noel., Air Polllution Control Engineering, McGrawHill, New York,1995.

ME 643 ADVANCED IC ENGINES (3 – 0 – 0) 3

Engine design and operating parameters – Thermo chemistry of fuel air mixtures- properties of working fluids.

Ideal model of engine cycles – cycle analysis with constant specific heats – Volumetric efficiency – Super charging and Turbo charging

Fuel intake systems and combustion in SI and CI engines – Carburetor and fuel injection systems – Squish prechamber engine flows.

Pollutant formation and control in IC engines - Types of diesel combustion system – Fuel spray behavior – Ignition delay.

Engine friction and lubrication – measurement of friction – fluid mechanics based multi dimensional models – Engine operating characteristics.

References:

1. Heywood, J.B., *Internal Combustion Engine Fundamentals,* McGraw-Hill, 1988.
2. Taylor, C.P., *The Internal Combustion Engines in Theory and Practice,* Vol-2, MIT press, 1985.
3. Ganesan, V., *Internal Combustion Engines, 2nd* ed., Tata McGraw-Hill, 2003.

ME 671 ENVIRONMENTAL POLLUTION CONTROL (3 – 0 – 0) 3

Classification and properties of air pollutants – Pollution sources – Effects of air pollutants on human beings, Animals, Plants and Materials - automobile pollution hazards of air pollution-concept of clean coal combustion technology - ultra violet radiation, infrared radiation, radiation from sun-hazards due to depletion of ozone - deforestation-ozone holes-automobile exhausts-chemical factory stack emissions-CFC.

Classification of water pollutants-health hazards-sampling and analysis of water-water treatment - different industrial effluents and their treatment and disposal –advanced wastewater treatment - effluent quality standards and laws- chemical industries, tannery, textile effluents-common treatment.

Hazardous waste management in India-waste identification, characterization and classification-technological options for collection, treatment and disposal of hazardous waste-selection charts for the treatment of different hazardous wastes-methods of collection and disposal of solid wastes-health hazards-toxic and radioactive wastes incineration and vitrification - hazards due to bio-process-dilution-standards and restrictions – recycling and reuse.

Sampling and analysis – dust monitor – gas analyzer, particle size analyzer – lux meterpH meter – gas chromatograph – atomic absorption spectrometer. Gravitational settling chambers-cyclone separators-scrubbers-electrostatic precipitator - bag filter – maintenance - control of gaseous emission by adsorption, absorption and combustion methods- Pollution Control Board-laws.

Pollution control in process industries like cement, paper, petroleum-petroleum roductstextile-tanneries-thermal power plants – dying and pigment industries - eco-friendlyenergy.

References:

1. Rao, CS, “Environmental pollution engineering:, Wiley Eastern Limited, NewDelhi, 1992.
2. S.P.Mahajan, “Pollution control in process industries”, Tata McGraw Hill Publishing Company, New Delhi, 1993.
3. Varma and Braner, “Air pollution equipment”, Springer Publishers, Second Edition.