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

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# LIST OF ELECTIVES

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<td>Environmental Pollution Control</td>
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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.


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:


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


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:

**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.


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:

**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.


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:

**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.


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:**


**SEMESTER II**

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


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


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:

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:

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

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

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


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:

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 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


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


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.


References:

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:

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

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.


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:**

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

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:

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.


References:
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:

ME 638 INSTRUMENTATION (3 – 0 – 0) 3


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


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


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:


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.


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

References


Web references

Springer Verlag’s Link URL: http://www.springerlink.com/
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


References


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:

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:
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.


References: