MECHANICAL ENGINEERING DEPARTMENT

M.Tech. THERMAL ENGINEERING

Course of Study & Scheme of Examination
2016-17

Maulana Azad National Institute of Technology
Bhopal

M.TECH. IN THERMAL ENGINEERING

First Semester

Course Number	Subject	Scheme of Studies Periods per week			Credits
		L	T	P	
MTH511B	Advanced Mathematics	2	2	-	3
TH 512	Advanced Thermodynamics	3	-	-	3
TH 513	Advanced Heat & Mass Transfer	3	-	-	3
	Elective - 1	3	-	-	3
	Elective - 2	3	-	-	3
	Open elective-1	3	-	-	3
TH 514	Thermal Engg Lab - I	-	-	2	2
TH 515	Seminar 1 and mini project	-	2	-	2
				Total credit	22

Second Semester

Course Number	Subject	Scheme of Studies Periods per week			Total Credits
		L	T	P	
TH 521	Instrumentation & Control	3	-	-	3
TH 522	Thermal Environmental Engg	3	-	-	3
TH 523	Theory and Design of Heat Exchangers.	3	-	-	3
	Elective - 3	3	-	-	3
	Elective - 4	3	-	-	3
	Open elective-2	3	-	-	3
TH 524	Thermal Engg Lab - II	-	-	2	2
TH 525	Seminar 2 and mini project	-	2	-	2
				Total credit	22

List of department electives

TH531 Numerical Heat Transfer
TH532 Experimental Stress Analysis
TH533 Maintenance of Thermal Power Plant Equipment
TH534 Refrigeration System and Component Design
TH535Theory and Design of Gas Turbines;
TH536 Combustion;
TH537 Vibrations and Its App for Design of Turbomachinery;
TH538 Theory & Des. Of Turbomachines
TH539 Gas Dynamics and Flow Through Turbomachines
TH540 Simulation Of I.C. Engine

List of Open Elective

TH551 Non-Conventional Thermal Energy System;
TH552 Thermal Power Plant Engineering;
TH553 Power Generation Systems

SYLLABUS

MTH511B ADVANCED MATHEMATICS

Complex Variables, Differentiation, analytic functions, Cauchy-Raimann equations, Conjugate functions and their application to two dimensional potential problems, Conformal transformation. Integration, Cauchy's theory, Zero's and poles residues, applications of residue theorem in integration. Differential Equations, Partial differential equations, solution by separation of variables. Diffusion equation. Heat flow in a bar, Wave Equation, Vibration of strings, vibration of circular membrane, Numerical Methods in Engineering, Solution of Polynomial Equation, Newton Raphson, Graffes's Braistow methods for nearly equal roots. Solution of Differential Equations: Runge –Kutta method for first and second order equations. Adam Bash forth methods for corrator and predictor. Numerical methods for partial differential equations of parabolic and hyperbolic type. Applications. FEM, Variational Functionals, Euler Lagranges equation, Variational forms, Ritz method, Glarkin's method, discretization. Finite elements method for one dimensional problems. Laplace Transforms, Elementary Laplace Transforms and theorem, solution of linear differential equations with constant coefficients. Heavyside unit functions, Direc delta function, their Laplace transforms and application to practical problems, Fourier integrals.

References

1. Engineering Maths — Shrivastava & Dhavan
2. Engineering Maths — B.S. Grewal

TH 512 ADVANCED THERMODYNAMICS

Laws of Thermodynamics, Differential Equations of Thermodynamics, Changes in States of Gases at their Transferences, Throttling process. Joule Thomson effect. Temperature of braking. Mixtures of ideal & real gases. Equilibrium of Thermodynamic System, Equations of states for real gases Vanderwaal's equation of state. Clayperon equations. Gibbs phase rule. Law of corresponding states.Fundamentals of Chemical Thermodynamics, First law of thermodynamics in thermochemistry. Heat effects of reaction. Hess's law. Kirchhoff's law. Chemical equilibrium. Bond energy

References

1. Engineering Thermodynamics Wan Wylen
2. Engineering Thermodynamics G. Rogers & Y. Mayhow

TH 513 ADVANCED HEAT & MASS TRANSFER

Transient Heat Conduction, Convection, Heat Transfer by Radiation, Boiling and Condensation,nucleate pool boiling and empirical correlations for pool boiling heat transfer, factors affecting pool boiling film coefficients, high heat flux boiling. Laminar film condensation on a vertical plate, turbulent film condensation, drop wise condensation. Numerical Solution of Conduction problems and Mass Transfer, Finite difference equations method of energy balance, finite difference formulation of unidirectional for Cartesian cylindrical coordinate of various kind of boundary conditions, heat conduction problems, numerical methods of solutions, numerical solution of transient heat diffusion problems. Convective mass transfer, equations for convective mass transfer, boundary layer mass transfer empirical correlations for convective mass transfer.

References

1. Principles of Heat Transfer — Kreith Bohn
2. Heat Transfer — J.P. Holman

TH 514 THERMAL ENGINEERING LABORAYORY

Experiments in heat transfer and IC engines.

TH515 SEMINAR 1

Students have to collect a International Journal paper on the topics of their interest, prepare a write up and present with suitable demonstration by software or experimental work. Evaluation will be based on relevant topic student has studied, communication skill and reporting/documenting procedure

SECOND SEMESTER

TH 521 - INSTRUMENTATION AND CONTROL

Theory and Experimentation in Engineering, Fundamentals of Measurement System, Performance Characteristics of Instruments: Dynamic performance characteristics: dynamic response, system transfer function and frequency response control actions. Elements of Measurement Systems, Signal conditioning, Data presentation systems, Pneumatic and Hydraulic systems, Applied Mechanical Measurements, Determination of count, events per unit time and time intervals, Measurement of stress and strain, Pressure, Torque and power measurements.Flow Measurements: Flow Visualization, shadowgraoh, schlieren and interferometric techniques, pitot static tubes, hot wire anemometers, Laser Doppler Velometer, flow measurements using coriolis effect. Temperature and Heat Flux Measurement: Thermoelectric sensors, Electric resistance sensors, Thermistors, Radiations pyrometers, Temperature measuring problems in flowing fluids, dynamic compensation.

References

1. Industrial Instrumentation — Al Seutko, Jenny D Frank
2. Instrumentation Measurements and Analysis — B.C. Nakva K. K. Chandhary

TH 522 - THERMAL ENVIRONMENTAL ENGINEERING

Thermodynamic properties of moist air, psychrometric chart and its applications. Thermal exchanges of body with environment. Physiological hazards resulting from heat exposure. Environmental requirements for various components (e.g. men, material, machinery, and processes) for a few important heavy industries. Various systems of refrigeration and their application to environmental control. Vapour compression refrigeration system, Multi evaporator multi compressor systems, Vapour absorption system, Evaporative Cooling, Desiccant cooling systems. Various system of ventilation for industry. Air conditioning load calculations, various systems of air conditioning for industries. Recommendations of ISO 140000 for thermal environment.

References

1 Refrigeration and Air Conditioning — Arora and Domkundwar

2. Refrigeration and Air Conditioning — C.P. Arora

TH523 - THEORY AND DESIGN OF HEAT EXCHANGERS

Classification, temperature distribution for parallel flow, counter flow, cross flow, heat exchanger, evaporators and condensers, concept of LMTD and overall heat transfer coefficient. Fouling of heat exchangers, NTU method for gauging exchanger performance, LMTD for parallel, counter and cross flow heat exchangers, effectiveness for parallel and counter flow exchangers. Important design considerations: material selection and optimization of heat exchangers, analysis of regenerative heat exchangers. Vibrations induced by flow, International Standards for heat exchangers.Thermal and Mechanical Design of Shell & tube heat exchangers, Double pipe, Extended surface, Condensers & evaporators, Boilers & feed water heaters, Air preheaters, Dictators, Heat exchanger for nuclear application.

References

1. Design of Heat Exchanger — Kern
2. Principles of Heat Transfer — Kreith Bohn

TH524 THERMAL ENGINEERING LABORATORY 2

Experiments in heat transfer and IC engines.

TH525 SEMINAR 2 & mini project

Students have to collect a International Journal paper on the topics of their interest, prepare a write up and present with suitable demonstration by software or experimental work. Evaluation will be based on relevant topic student has studied, communication skill and reporting/documenting procedure

DEPARTMENT ELECTIVES

TH 531 NUMERICAL HEAT TRANSFER

Introduction, Chemical thermodynamics and chemical kinetics. Conservation equations for multi-component systems. Premixed systems,

Detonation and deflagration, laminar flames, effects of different variables on burning velocity, methods for measuring burning velocity, flammability limits, ignition and quenching turbulent pre-mixed flames. Non-premixed systems, Laminar diffusion flame jet, droplet burning. Combustion of solids, Drying, devolatilization and char combustion. Practical aspects of coal combustion.

References

1. Combustion — Irvin Glassman
2. Intoduction to combustion — Stephen Turns

TH 532 EXPERIMENTAL STRESS ANALYSIS

Stress and Strain, Principle stresses, Mohr's stress circle, Isoclinic, Isostatic, Isochromatic, Isopachic, stress strain relationship. Whole field method, laws, plane polariscope, circular polariscope, white light illumination, analysis of photoelastic data, stress coat and membrane analogy, Electrical wire resistance strain gauges. Strain Gauge Rosette, Types of rosette, four element rectangular rosette, Tee-delta rosette, rosette analysis. Application, Design of turbo machinery components such as steam turbine rotor, L.P. and H.P. cylinder diaphragm value rotary compressors and its parts. Fatigue testing and vibration studies.

References

1. Experimental Stress Design — Daly and Reilly
2. Experimental Stress Design — Sadhu Singh

TH 533 MAINTENANCE OF THERMAL POWER PLANT EQUIPMENTS

Maintenance Management, Maintenance strategies, maintenance schedule, emergency maintenance procedure spare part management, Diagnostic Maintenance and Machine Health Monitoring, practical application of diagnostic maintenance to specific industrial machinery and plants. Various techniques of condition monitoring wear analysis, vibration and noise signature, thermography etc. Mechanism of Lubrication & Lubricants, Lubrication Regimes: Lubrication regimes, analysis and modes of lubrication in different bearings, squeeze films, fluid film, elasto-hydrodynamic and boundary lubrication. Failure Mechanisms and Analysis, Material failure and failure due to environmental effects, Design faults, analysis of engineering failures, failure due to abuse of machinery, failure of seals & packing, failure of bearings, failure of gears, fatigue failure, failure due to time – temperature effects (creep) corrosion etc. Maintenance of Power Plant Machinery, Predictive and preventive maintenance of steam turbine and its components. On load and off load cleaning of condenser tubes. Maintenance scheduling of cooling water plants, cooling towers.

References

1. Maintenance & Spare Parts & Management P. Gopal Krishnan
2. Modern Power Station Practice10 Volumes in Reference British Electricity Int. Ltd

TH 534 REFRIGERATION SYSTEM AND COMPONENT DESIGN

Introduction to various components. Thermal design of reciprocating, centrifugal and screw compressors. Capacity control methods. Thermal design of different evaporators–DX, flooded, etc. Thermal design of condensers–water-cooled and aircooled. Sizing of capillary. Selection of expansion valves and other refrigerant control devices. Components balancing. Testing and charging methods. Design of absorber and generator of vapor absorption systems. Design of cold storages, mobile refrigeration, refrigerators, commercial appliances.

References

1. Refrigeration and Air Conditioning C.P. Arora C.P.
2. Principles of refrigeration R.J. Dossat

TH535 THEORY AND DESIGN OF GAS TURBINES

Gas Turbine Plants, Axial Flow Compressor, Principle of operation, velocity triangles. Design procedure for single and multistage compressors. Three dimensional effect compressor performance. Description and problems of transonic and supersonic compressors. Impulse turbine. Single and multiwheel turbine efficiency, Number of stages blade passages, Vortex design of turbine blades. Blade design & manufacture blade material and blade cooling, limiting factors in turbine design. Combustion in Gas Turbine and Turbine Characteristics

References

1. Gas Turbine — Cohan Rogers
2. Gas Turbine — Ganesan

TH 536 COMBUSTION

Introduction: Mathematical Background, Survey of Numerical Methods Used in Heat Transfer, Finite Difference Methods, Finite Element Methods, Simulation of Transport Process, Conduction Heat Transfer, Steady and unsteady state one & two dimensional problems. Explicit, Implicit and Crank-Nicolson scheme, ADI and ADE methods. Convection Heat Transfer, Boundary Layer Flows, Similarity solutions, Derived Variables, Patankar/Spalding Methods for two-dimensional flows.Elliptic Solutions**,** Control Volume formulation. Energy and other scalar equations, Momentum equations, Segregated Solution method; SIMPLE & SIMPLER schemes, Stream Function – Vorticity Transport method. Turbulence, Examples of turbulent flows, Stress relations, Reynolds stresses, turbulence model computations, Analogy between Heat Transfer and Momentum, Linearization of source terms.

References

1. Computational Fluid flow and Heat Transfer K. Muralidhar, T. Sundarajan
2. Numerical Heat Transfer S.V. Patankar

TH 537 VIBRATIONS AND ITS APPLICATION FOR DESIGN OF TURBO MACHINERY

Differential equations of motion for first order and second order linear systems. Transverse vibration of beams. Damped free vibration, viscous, coulomb damping dry friction logarithmic decrement. Forced vibration of single degree of freedom linear systems. Response of first order systems to harmonic excitation. Frequency response. Response of second order systems to harmonic excitation. Rotating unbalance, whirling of rotating shafts. Harmonic motion of the base, vibration isolation, transmissibility, force transmission to foundations. Vibration measuring instruments eg Seismic mass, vibrometer, Accelerometer. Energy dissipation. Forced vibration with coulomb hystersis or structural & viscous damping. Equation of motion for a two degrees of freedom system. Torsional vibration of one, two and three rotor system. Equivalent shafting. Torsional vibration of a geared system. Torsional vibration with harmonic excitation, Critical speed of a shaft having a single disc with damping.

References

1. Mechanical Vibrations G.K. Grover

2. Theory of Vibration with Application Thomson

TH538 THEORY AND DESIGN OF TURBOMACHINES

Energy interchange in fluid machinery, momentum-principle, streamline theory, momentum and circulation. Theory of centrifugal impeller for incompressible fluid, velocity triangle - impleller for approach and prerotation vortex theory. Blower casing volute, vaned and vaneless diffuser, thermodynamics of turboblowers. Dimensionless characteristic of turboblowers. Axial Flow Compressors. Two dimensional Cascade: Theoretical analysis of performance and experimental works. Howell's and Cartter's correlations for low speed. Effect of Reynolds and Mach numbers. Pitch line design of axial flow compressor. Radial equilibrium. Calculation of losses and stage efficiencies. Stresses in the discs and blades - interstage traversing, measurements of total and static pressures and vane angles.

Transonic and supersonic compressors. Industrial Steam Turbines. Type of Industrial Steam Turbines.

References

1. Turbines Fans and Compressors S.M. Yahya
2. A Practical Guide to Steam Turbine Technology - Heinz P. Bloch

TH 539 GAS DYNAMICS AND FLOW THROUGH TURBOMACHINES

Fundamental Equations of Steady Flow, Euler's equation, Bernoulli's equation, Energy equation, Stream Function and Velocity Potential Potential Flow, Elementary potential flows, Uniform flow, Source, sink, vortex and doublet. Superposition of flow patterns. Flow over immersed bodies. Development of the aerofoil-lift and drag, Kutta-Joukowski Profile, pressure distribution over aerofoil blading. Viscous Flow, Navier Stoke's equation and exact solutions of steady flow problems. Flow through pipes, flow over flat plates. Laminar and turbulent boundary layers. Dimensional analysis. Compressible Flow of Gases, Fanno line and Rayleigh line flows. Flow with normal shock waves governing equations, Prandtl Meyer and Rankine Hugoniot relations, Moving normal shock waves. Cascade Tests, Fundamental equation of flow through turbo machinery. Radial equilibrium equation. Vortex flow through turbo machines. Surging and choking.

References

1. Fundamentals of Compressible Flows Yahya
2. Compressible Fluid Flow Michel A. Saad

TH 540 SIMULATION OF I.C. ENGINE:

AIM : To impart knowledge on simulation of various I.C engine processes.

OBJECTIVE : To learn the simulation of engine combustion based on first and second law of thermodynamics.

UNIT – I INTRODUCTION

First and second laws of thermodynamics – Estimation of properties of gas mixtures -Structure of engine models – Open and closed cycle models - Cycle studies

UNIT – II SIMULATION PRINCIPLES

Chemical Reactions, First law application to combustion, Heat of combustion – Adiabaticflame temperature, Chemical Equilibrium and calculation of equilibrium composition - Heat transfer in engines – Heat transfer models for engines.

UNIT – III SIMULATION OF COMBUSTION IN SI ENGINES

Combustion in SI engines, Flame propagation and velocity, Single zone models – Multi zonemodels – Mass burning rate, Turbulence models – One dimensional models – Chemicalkinetics modeling – Multidimensional models.

UNIT – IV SIMULATION OF COMBUSTION IN CI ENGINES

Combustion in CI engines Single zone models – Premixed-Diffusive models – Wiebe' model– Whitehouse way model, Two zone models - Multizone models- Meguerdichian and Watson's model, Hiroyasu's model, Lyn's model – Introduction to Multidimensional and spray modeling.

UNIT – V SIMULATION AND GAS EXCHANGE PROCESSES AND ENGINE FRICTION

Thermodynamics of the gas exchange process - Flows in engine manifolds – One dimensional and multidimensional models, Flow around valves and through ports Models for scavenging in two stroke engines – Isothermal and non-isothermal models.

TEXT BOOKS :

1. Ashley S. Campbell, Thermodynamic Analysis of Combustion Engines, John Wiley and Sons, 1980.
2. V.Ganesan, Computer Simulation of Spark Ignition Engine Processes, Universities Press, 1995.

References

1. Ashley S. Campbell, Thermodynamic Analysis of Combustion Engines, John Wiley and Sons, 1980.
2. V.Ganesan, Computer Simulation of Spark Ignition Engine Processes, Universities Press, 1995.
3. V.Ganesan, Computer Simulation of Compression Ignition Engine Processes, Universities Press, 2002.
4. Gordon P. Blair, The Basic Design of two-Stroke engines, SAE Publications, 1990.
5. Horlock and Winterbone, The Thermodynamics and Gas Dynamics of Internal Combustion Engines, Vol. I & II, Clarendon Press, 1986.
6. J.I.Ramos, Internal Combustion Engine Modeling, Hemisphere Publishing 7. Corporation, 1989.
7. J.N.Mattavi and C.A.Amann, Combustion Modeling in Reciprocating Engines, Plenum Press, 1980.

OPEN ELECTIVE

TH 552 THERMAL POWER PLANT ENGINEERING

Siting of Power Stations & Plant Layout, Power Plants Economics, Load curve, Load duration curve, Load factor and diversity factor. Effect of load curve and diversity factor on the performance of power plant.Duct Work,Piping and Insulation, Design and layout of ducting for air, fuel, Pipe insulation. Optimum and Economic thickness. Specification of insulation. Power Plant Components,

Radiant superheaters and reheaters, economizer and preheaters. Plant Instrumentation, General & Special Instrumentation, centralized & automatic control equipment, types of controls.Supercritical Power Stations, principle of working, Power Plant Testing, Preliminary performance checks, acceptance tests for various components. Power Plant Management:Operation and Maintenance of Turbines**:**

Starting, loading and stopping of turbine, normal operation checks, maintenance logging, parallel operation.

References

1. Power Plant Engineering - Arora & Domkundwar
2. Power Plant Engg - P.K.Nag