6th SEM

Uttarakhand Technical University, Dehradun

New Scheme of Examination as per AICTE Flexible Curricula

Plastic and Polymer Engineering, VI-Semester

BPPT-601	**Polymer Rheology**	**L**	**T**	**P**
BPPP-601		**3**	**1**	**2**

Objectives:

1. To understand the basic concepts of rheology
2. To analyze the flow behavior of polymer melts and to carry out the experimental techniques for measuring the rheological properties.
3. To understand the basics of fluid mechanism and to analyze behavior of Newtonian fluids.
4. To experimental with instruments such as MFI, CapillaryRheometer, Cone and plate viscometer.

Course Outcome:

1. Understand polymer melt flow behavior and to bring out co-relation between polymer rheology and polymer processing
2. Apply the concept of effect of various flow profiles on viscosity and thus study the effect on polymer properties.
3. Choose the right processing conditions for various processing techniques
4. Carry out rheological testing and correlate them to set the processing parameters and also choose the right polymeric grade during processing.
5. Interpret the practical data and analyze it using certain mathematical models.

Detailed Content:

Unit –I :

Introduction to Polymer Rheology

Introduction to Rheological principles , Definition and importance of Rheology, types of fluids, time dependent fluids , time independent fluids ,viscous elastic fluids Normal stress difference and Weissenberg's effect.Introduction to tensors , stress tensors and strain tensors, Basic equations of fluid mechanics-Continually equation, Cauchy's equation.

Unit –II :

Rheology in Polymer Processing

Viscosity and processing-Injection molding, Extrusion, Compression moulding.Non-Newtonian flow, practical melt viscosities, simple shear flow, Melt-flow index.Simple elongational flow and its significance. Dynamic flow behavior. Power law fluid Model.

Unit –III :

Viscoelastic Behavior

The elastic and viscoelastic state of polymers, Stress relaxation , relaxation modulus, creep compliance dynamic modulus. Mechanical models – Maxwell model, Voigt-Kelvin model, Boltzmann Principle of Superposition. WLF equation. Dynamic mechanical testing.

Unit –IV :

Parameters Influencing Polymer Rheology

Effect of pressure and molecular weight on viscosity, Effect of temperature, molecular at dependence of zero shear viscosity ,crosslinking, crystallinity branching, copolymerization and plasticizers. Shear rate dependence of viscosity.

Melt Flow Analysis

Laminar flow through circular cross section, parallel plates. Rheological models for extensional viscosity. Flow mechanism :-Drag, pressure and leak flow.

Unit –V :Rheometry

Basic concept of constant stress and constant strain ,Different types of Rheometers-Cone and plate rheometer, Concentric cylinder rheometer, Parallel disk rheometer, Concentric rotating disk rheometer, Controlled stress rotational rheometer, Torque rheometers-Extruder type

Reference Books:

1. Introduction to Polymer Viscoelasticity by J. Aklonis and W. J. Macknight, John Wiley & Sons(2005).
2. Polymer Science and Technology of Plastic and Rubber by P. Ghosh, Tata McGraw Hill (2010).
3. Fundamental Principles of Polymeric Materials by S.L. Rosen, Wiley-Interscience (2012).
4. Melt Rheology and Its Role in Plastic Processing by J. M. Dealy and K.F. Wissbrum, Springer(1999).
5. Applied Rheology in Polymer Processing by B. R. Gupta, Asian Books (2004).

Suggested Experiments:

1. Determination of Melt Flow Index of different Plastics Materials.
2. Determination of Viscosity of polymer by cone plate rheometer.
3. Determination of Viscosity of polymer by parallel plate rheometer.
4. Study of Rheological behavior of Polymer gel.
5. Study of viscosity of various thermoset and thermoplastic polymers by Brookfield viscometer.
6. Determination of viscosity of PVC polymers by Ostwald viscometer.
7. To determine the viscoelastic properties of the given samples.
8. Determination of molecular weight by viscosity.

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Plastic and Polymer Engineering, VI-Semester

BPPT-602	**Plastic Product and Mould Design**	**L**	**T**	**P**
BPPP-602		**3**	**1**	**2**

Objectives:

1. Understand the basics of Plastics mould design and also product design.
2. Acquire knowledge about various moulds for different processing techniques.
3. Understand the knowledge of design parameters of an Injection mould.
4. Understand various design parameters for a split mould .
5. Design the extrusion dies for pipes and sheets

Course Outcome:

1. Understand the various concepts, factors and design criteria used in the design of various types of plastic products and injection moulds and extrusion dies.
2. Select the plastic materials based on end use applications of products
3. Design plastic products for different working conditions with geometrical and financial considerations
4. Design of injection moulds, compression moulds, transfer moulds, blow moulds and extrusion dies as per specifications

Detailed Content:

UNIT-I

Design of polymeric product. Design criteria based upon product functions and geometry. Material selection by property assessment. Selection of appropriate forming processes. Moulding considerations: Draft, radii, dimensional tolerances, wall thicknesses, ribs and bosses, inserts, sink marks, undercuts, feeding system, gate location, flow pattern, shrinkage and post moulding shrinkage.

Unit-II

Design of Plastic under static load; Design of Plastic under Dynamic load – Gear Bearing. Metal insert, hinge, fasteners.

Unit-III

Injection mould design: Single, multicavity, semi-automatic and automatic moulds. Types of injection mould, their application, detailed structure and working. Feed system, Temperature control system, Ejection System, Standard Mould base.

Unit – IV

Split Mould and types of mechanism, Unscrewing mechanism, Introduction to Hot Runner mould. Design concepts for compression moulds, transfer moulds and blow moulds.

Unit -V

Extrusion Dies - Types of extrusion dies and design characteristics. Die Design for Pipe and sheets.

Reference Books :

1. David H Morton Jons John Wellis "Polymer product design materials and processing" Hanser Publication

2. Rao NS "Design data for plastics engineers"(2000)

3 Bebb,R.H., "Plastics Mould Design," Vol.1, Compression and Transfer Moulds, (2006)

4. Pye R.G.W., "Injection MOULD Design for Thermoplastics" (1968)

Suggested Experiments:

I. Mould Design using CAD

a) Injection Mould design: Design calculations for No. of cavities, Selection of injectionmoulding machine, shot capacity, plasticizing rate, Clamping force and 2 D / 3 D Modeling for Two plate, Three Plate and split Moulds

b) Compression Mould Design: Design calculations for No. of cavities, Flash thicknessallowances, Design of loading chamber, Bulk factor, Pressure pad, Heaters and 2 D / 3 DModeling for Compression Mould.

c) Transfer Mould Design: Design calculations for Pot, Bulk factor, Heaters and 2 D / 3 DModeling for Pot and Plunger transfer Moulds.

d) Blow Mould Design: Design calculations for Clamping force, pinch-off, Head die design,Parison dimensions and 2 D /3 D Modeling for Blow Mould.

II. CAM Programming

Programming and Machining of mould elements (Core, Cavity, Gide Pillar and Guide Bush)using CNC Turning Center and CNC Machining Center.

III: Mould flow Analysis

a) Design Optimization of Plastic Part, Mould and Process parameters optimization using Mold flow Software

b) Modeling, Mesh Creation, Mesh Checking, Surface repair, Creating Feed system andcooling system.

c) Analysis: Gate location, Moulding window Fill, Flow, Cool, Pack, Warp, Shrinkage, Stress

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Plastic and Polymer Engineering, VI-Semester

BPPT-603	**Plastic Processing-II**	**L**	**T**	**P**
BPPP-603		**3**	**1**	**2**

Objectives:

1. Understand the concepts of thermoset injection molding.
2. Acquire knowledge of processes for manufacturing of different Plastic foams.
3. Understand the concepts of gas & water Injection molding.
4. Acquire knowledge about various forms of plastics laminates.
5. Explain the phenomenon of sandwich mounding.

Course Outcome:

1. Understand principle, construction features of processing equipment's, controllable process parameters and theory of standard operation involved during processing of thermoplastic and thermoset materials
2. Set the process with respect to materials:
    - Optimize the processing parameters based on the quality of the molded products.
    - Identify the defects in the products and suggesting suitable remedial action.
3. Analyze the importance and effect of various process variables affecting the product quality.
4. Calculate the process output and cycle time for different process.
5. Explain the process involved with Injection Molding, Blow Molding, Thermoforming, Rotational Molding, & FRP Process.
6. Analyze the appropriate processing technique to suit to produce desired product at optimum cost.

Detailed Content:

UNIT-I

Basic concepts of injection moulding for thermoplastics. Machine layout, construction and specification, type of injectionunits. Principle and theory of standard operation, elements of moulding cycle, screw plasticizing and conveying output, screw driver principles, outline of mould features, clamping devices-hydraulic and toggle types.

Unit – II

Process variables and their importance, temperature, pressure, injection rate, etc. Faults and remedies in injection moulding. Injection moulding of thermosets. Reaction injection moulding.

Unit - III

Description of various thermoforming processes-simple vacuum, drape, bubble and plug assisted forming's. Thermoforming and process variables affecting the product quality. Machining of Plastics

Unit – IV

General description of blow moulding processes, type of blow moulding machines, parison control, types of Dies, process variables, problems and their remedies. Stretch blow moulding.

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Plastic and Polymer Engineering, VI-Semester

Unit - V

Rotational moulding- description and features of rotational moulding and its comparison with blow moulding. Welding / Joining of Plastics - Definition, Principle of Working ; FRP Processes - Hand lay, Spray, Autoclave, Filament winding, Pultrusion , Matched mold - Principal & working. Faults and remedies.

Reference Books;

1. Injection Moulding Handbook, Dominick V. Rosato and D.V.Rosato, CBS Publisher (2000)
2. Polymer Processing by Morton and Jones, Chapman & Hall, (2007)
3. Thermoforming by J.L.Thorne, Hanser Publishers, (1988)
4. Rotational Molding by Glenn L. Beall, Hanser Publishers, (1998)

Suggested Experiments:

1. Auto Injection Moulding Process – Free sketch of Machine, Study of Parts & their function. Cycle time analysis, Start up and shut downProcedure.
2. Micro-Processor Controlled Injection Moulding Process – Free sketch of Machine, Study of Parts & their function. Cycle time analysis, Start up and shut downProcedure.
3. Extrusion Process – Free sketch of Machine, Study of Parts & their function. Practice on Die setting, Cycle time analysis, Start up and shut downProcedure.
4. Compression Moulding or Transfer Moulding Process – Free sketch of Machine, Study of Parts & their function. Cycle time analysis, Start up and shut down Procedure.
5. Blow moulding Process – Free sketch of Machine, Study of Parts & their function, Parison die. Practice on Die centering, Cycle time analysis, Start up and shut downProcedure.
6. Thermoforming (Vacuum forming) Process – Free sketch of Machine, Study of Parts & their function. Cycle time analysis, Start up and shut down Procedure.
7. Rotational Moulding Process – Free sketch of Machine, Study of Parts & their function. Cycle time analysis, Start up and shut downProcedure.
8. Plastics coating Process – Free sketch of Machine, Study of Parts & their function. Cycle time analysis, Start up and shut downProcedure.
9. Plastics Sealing Process – Free sketch of Machine, Study of Parts & their function. Cycle time analysis, Start up and shut downProcedure.
10. Plastics welding Process – Free sketch of Machine, Study of Parts & their function. Cycle time analysis, Start up and shut downProcedure.
11. Screen-Printing onPlastics
12. Hand lay Process for FRP – Study of resin and other components. Making of a product.

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Plastic and Polymer Engineering, VI-Semester

BPPT-604(A) Additives and Compounding	**L**	**T**	**P**
	3	**1**	**0**

Objectives:

1. To enable the students to learn about the various drawback of polymer materials and suitable remedies.
2. To understand the mechanism of degradation of polymers and stabilizing additives.
3. To develop the knowledge of various compounding methodologies for plastics materials and learn the maintenance of compounding machinery.

Course Outcome:

1. Understand various aspects of polymer additives and their merits and demerits.
2. Understand various compounding methods used in the manufacturing of compounded thermoplastics and thermosets.
3. Acquire knowledge about various selection criteria for polymeric additives.
4. Analyze the properties of various additives and vulcanizing agents to produce a rubber of desired properties.

Detailed Content

Unit -I

Introduction

Basic concept of Additivesand compounding, merits and demerits of additives in polymer matrices.Selection criteria of additives for commercial polymers.

Unit – II

Additives for plastics and their mechanism of function:

Stabilizers ,Fillers, Plasticizers, Lubricants, Flame retardants, Foaming agents, Cross Linking agents, Metal deactivators, Pelletizers .

Unit – III

Additives for rubbers and their mechanism of function:

Vulcanizing agents and retardants,Accelerators,Activators,Fillers,Softeners,Colors and pigments,Tackyfing agents,Blowing agents,Surface properly modifiers

Unit –IV

Fundamentals of Compounding

Compounding- selection of polymers and compounding-ingredients-general.Mixing: Types of mixing, concept and importance of master batches. Mixing of additives with the polymers, melt compounding and calendaring.

Unit –V

Mixing Equipment's and its Mechanisms

Mixing and mixing equipment's. Compounding by batch mixer- High speed mixer -Two roll millBanbury Mixer -Ribbon blender – Planetary mixers. Compounding Machineries specifications temperature control system - operating characteristics and working details of continuous mixers-Single Screw & twin Screw Extruders and maintenance of Compounding machines.

Reference Books:

1. Polymer Modifiers and Additives, by Lutz, Dekker (2001)
2. Chemistry and Technology of Polymer Additives, by Al-Malaika, Elsevier Applied science(1999).
3. Plastic Materials, by J. Brydson, Butterworth-Heinemann(1999).
4. Handbook of Rubber Technology, by Martin and Smith, CBS Publishers(2007).
5. Polymer Science and Technology: Plastic, Rubber Blends and Composites, by P. Ghosh, Tata McGraw Hill (2010)

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Plastic and Polymer Engineering, VI-Semester

BPPT-604(B)	**Adhesives And Surface Coatings**	**L**	**T**	**P**
		3	**1**	**0**

Objectives:

1. To develop the knowledge of Adhesives and Surface Coatings
2. To enable the students about various application and properties of Surface coating.
3. To create the knowledge to select suitable adhesive and joint design for specific applications.

Course Outcome:

1. Understand the basic concept of adhesion, adhesive joints, mechanism of adhesion process, principles of adhesive formulation , their production & evaluation techniques.
2. Formulate and select production techniques for different adhesives for different applications like packaging ,automotive, aerospace etc.
3. Acquire knowledge about the Raw materials, manufacturing technology, quality control tests involved during the manufacture of surface coating materials
4. Identify specific method to synthesize a polymer for a new paint /varnish suitable to specific application.
5. Analyze the various physical, chemical and electrical properties of various surface coating materials.

Detailed Content

Unit-I

Adhesives,conceptsandterminology,functionsofadhesives,advantagesanddisadvantagesof adhesivebonding,criteriaforselectionofadhesives.Types of adhesives, structural adhesives, Urethane structured adhesives, Modified acrylic structural adhesives, phenolic adhesives and modifiers, anaerobic adhesives, cyanoacrylate Adhesives,Hotmeltadhesives,pressuresensitiveadhesives,RTVSiliconeadhesives,sealants, water basedadhesives.

Unit-II

Specialty adhesives, adhesives in aerospace, adhesive in automobile industry, conductive adhesives, adhesives in building construction, adhesive in electrical industry.Joint design, stress, types of joints, selection of joint detail, joint criteria, surface preparation of adherend -metals, plastics and rubbers. Adhesive bonding process- methods for adhesives applicationandbondingequipment,testingandqualitycontrol.

Unit-III

Introduction to surface coatings

Componentsof paints. Pigments, pigment properties, different types, extenders, solvents, oils, driers, diluents, lacquers, varnishes, paint preparation, formulation, factors affecting pigment dispersion, preparation of pigment dispersion.

Unit-IV

Different types of paints

Classificationbasedonpolymeric resin,emulsion,oilandalkydpaints,acrylic paints,epoxy coatings, polyurethane, silicones, chlorinated rubbers. Classification based on application, Fluro polymers, vinyl resins, appliance furnishes, automotive finishes, coil coatings, can coatings, marine coatings,aircraftcoatings.Surfacepreparationandpaintapplication.

Unit-V

Paintpropertiesandtheirevaluation,mechanismoffilmformation,factorsaffectingcoating properties, methods usedforfilmpreparation,barrierproperties,opticalproperties,ageing properties, rheological propertiesandadhesionpropertiesofcoatings.

References Books: -

1. HandbookofAdhesives–Skeist,Irvind,VanNistrand,NewYork,1990,3rdEditionGeraldL. Schreberger,Adhesiveinmanufacturing,MarcelDekkerInc.,NewYork,1983
2. W.C.Wake,Adhesionandtheformulationofadhesives.AppliedSciencePublishers,London, 1976
3. SwarajPaul,SurfaceCoatings,JohnWiley&Sons,NY,1985.
4. GeorgeMathews,PolymerMixingTechnology,AppliedSciencePublishers.Sheilds,Hand bookofadhesives, Butterworths,1984.

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Plastic and Polymer Engineering, VI-Semester

BPPT-604(C)	Polymer Degradation And Stabilization	L	T	P
		3	1	0

Objectives:

1. To enable the students to learn about various aspects of degradation.
2. To understand the mechanism of degradation of polymers.
3. To develop the knowledge of biodegradation of polymers.

Course Outcome:

1. Understand the thermal degradation of polymer
2. Understand various aspects of mechanical and Ultrasonic degradation
3. Acquire knowledge of degradation of plastics by the effect of light.
4. Understand knowledge of the phenomenon of biodegradation of polymers.
5. Understand the knowledge about Chemical methods of degradation of polymers.

Detailed Content

Unit-I

Introduction and Thermal Degradation

Definition,ModesofPolymerDegradation, Mechanistic Aspects,SingleStepProcessandChain Reactions, Auto Oxidation, Random and Specific SiteAttack

Thermal Degradation

Introduction, Methods for Evaluation of Heat Resistance (DTA, DSC, TGA, TMA), Mechanistic Aspects, Heat Resistance Polymers, Ablation, Stabilization, Thermal Degradation and Recycling, Heat Effect in Bio Polymers.

Unit-II

Mechanical Degradation and Ultrasonic Degradation

Introduction, Mechanistic Aspects, Degradation Studies, Polymer Degradation in Solution. Ultrasonic Degradation, Importance, Experimental Methods, Mechanism of Ultrasonic Degradation (Cavitation and Direct Effects), Degradation Studies (Detection of Transient Species and Molecular Weight Distribution) Application of Mechanical Degradation: Stress, Induced Chemical Alterations of Polymers, Mastication of Natural and Synthetic Rubber, Mechano Chemical Synthesis of Block and Craft Copolymers.

Unit-III

Photo degradation

Introduction, Mechanistic Aspects (Excited States, Free Radicals and Ionic Species, Energy Transfer and Energy Migration), Degradation in the Absence of Oxygen (Norrish Types I & II Reactions), Photo Oxidation (Auto Oxidative Process, Sensitized Degradation), Stabilization, and Application: Polymers with Predictable Life Time, Photo resists.

Unit-IV

Degradation by High Energy Radiation and Biodegradation

Introduction, Aspects of Radiation, Mechanistic Aspects, Simultaneous Cross Linking and Degradation, Radiation Stability and Protection Radiation Effects in the Bio Polymers, Application: Lithography, X – ray Resists in Contact Microscopy, Graft and Block CopolymerizationBiodegradation,ModesofBiologicalDegradation,EnzymaticDegradationin Bio Polymers (Polysaccharides, Proteins, MaliceAcids)MicrobialDegradationofSyntheticPolymers,GeneralApplicationsofBioDegradable Plastics,

ExamplesofBiodegradablePolyestersandPolyamides

Unit-V

Chemical Degradation

Introduction, Solvolysis, Polymer Characterization by Solvolysis, Stability of Polymer againstSolvolytic Agents, Commercial Applications, Ozonisation, Oxidative Degradation, Auto Oxidation of Polymers. Ionic Degradation: Alkaline Degradation of Poly Saccharides, Acidic Degradation of Polyaldehydes and Polyacetals, Cationic Degradation of Polypropylene Sulphide and Polyesters.

Reference Books:

1. W.Schnabel,PolymerDegradation-PrinciplesandPracticalApplicationsHansenPublishers, New York,1992.
2. Ann-ChristineAlbertsson,SamuelJ.Huang,"DegradativePolymersRecyclingandPlastic WasteManagement"MarcelDekker,NewYork,1995.

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Plastic and Polymer Engineering, VI-Semester

BMET- 605 (A) Robotics	**L**	**T**	**P**
	3	**0**	**0**

Objectives:

1. Toacquiretheknowledgeonadvance algebraic toolsforthedescriptionofmotion.
2. Todeveloptheabilitytoanalyzeanddesignthem option forarticulatedsystems.
3. Todevelopanabilitytouses software toolsforanalysisanddesignofroboticsystems

Course Outcome:

1. BeabletousematrixalgebraandLiealgebrafor computing the kinematicsofrobots.
2. Beabletocalculatetheforwardkinematicsandinversekinematicsofserialandparallelrobots.
3. BeabletocalculatetheJacobianforserialandparallelrobot.
4. Beabletodothepathplanningforaroboticsystem.
5. BeproficientintheuseofMapleorMATLABforthe simulation forbots.

Detailed Content:

Unit 1Introduction:
Need and importance, basic concepts, structure and classification of industrial robots, terminology of robot motion, motion characteristics, resolution, accuracy, repeatability, robot applications.

Unit 2 End Effectors and Drive systems:
Drive systems for robots, salient features and comparison, different types of end effectors, design, applications.

Unit 3 Sensors:
Sensor evaluation and selection, Piezoelectric sensors , linear position and displacement sensing, revolvers, encoders, velocity measurement, proximity, tactile, compliance and range sensing. Image Processing and object recognition.

Unit IV Robot Programming:
Teaching of robots, manual, walk through, teach pendant, off line programming concepts and languages, applications.

Unit V Safety and Economy of Robots:
Work cycle time analysis, economics and effectiveness of robots, safety systems and devices, concepts of testing methods and acceptance rule for industrialrobots.

Suggested Books:

1. Mittal RK, Magrath IJ; Robotics and Control;TMH
2. GrooverM.P,Weiss M, Nagel,OdreyNG; Industrial Robotics-The Appl□; TMH
3. Groover M.P; CAM and Automation; PHILearning
4. Spong Mark and Vidyasagar; Robot Modelling and control; WileyIndia
5. Yoshikava ; Foundations of Robotics- analysis and Control; PHILearning;
6. Murphy ; Introduction to AI Robotics; PHILearning
7. FU KS, Gonzalez RC, Lee CSG; Robotics □Control, sensing□;TMH
8. Shimon, K; Handbook of Industrial Robots; John Wiley &Sons,.
9. GhosalAshitava; Robotics Fundamental concepts and analysis;Oxford
10. Saha S; Introduction to Robotics;TMH

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Plastic and Polymer Engineering, VI-Semester

BMET- 605 (B) Optimization Techniques	**L**	**T**	**P**
	3	**0**	**0**

Objectives:

1. To understand the theory of optimization methods and algorithms developed for solving various types of optimization problems
2. To develop and promote research interest in applying optimization techniques in problems of Engineering andTechnology
3. To apply the mathematical results and numerical techniques of optimization theory to concrete Engineeringproblems.

Course Outcome:

1. Understand importance of optimization of industrial processmanagement.
2. Apply basic concepts of mathematics to formulate an optimizationproblem.
3. analyze and appreciate variety of performance measures for various optimizationproblems

Detailed Content:

Unit 1 Introduction to Optimization:

Engineering application of Optimization – Statement of an Optimization problem - Optimal Problem formulation - Classification of Optimization problem. Optimum design concepts, Definition of Global and Local optima – Optimality criteria - Review of basic calculus concepts – Global optimality

Unit 2 Linear programming methods for optimum design:

Review of Linear programming methods for optimum design –Post optimality analysis-Application of LPP models in design and manufacturing.

Unit 3 Optimization algorithms for solving unconstrained optimization problems:

Gradient based method: Cauchy's steepest descent method, Newton's method, Conjugate gradient method.

Unit-4 Optimization algorithms for solving constrained optimization problems:

Direct methods – penalty function methods – steepest descent method - Engineering applications of constrained and unconstrained algorithms.

Unit 5 Modern methods of Optimization:

Genetic Algorithms - Simulated Annealing - Ant colony optimization - Tabu search – Neural-Network based Optimization – Fuzzy optimization techniques – Applications.Use of Matlab to solve optimization problems.

Suggested Books:

1. Rao S. S. - 'Engineering Optimization, Theory and Practice' - New Age International Publishers - 2012 - 4th Edition.
2. Deb K. - 'Optimization for Engineering Design Algorithms and Examples' – PHI -2000
3. Arora J. - 'Introduction to Optimization Design' - Elsevier Academic Press, New Delhi -2004
4. .Saravanan R. - 'Manufacturing Optimization through Intelligent Techniques' - Taylor & Francis (CRC Press) -2006
5. Hardley G. -'Linear Programming' - Narosa Book Distributors Private Ltd. -2002

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Plastic and Polymer Engineering, VI-Semester

BMET- 605 (C) Renewable Energy Technology	**L**	**T**	**P**
	3	**0**	**0**

Objectives:

1. Understand the various forms of conventional energyresources.
2. Learn the present energy scenario and the need for energyconservation
3. Explain the concept of various forms of renewable energy
4. Outline division aspects and utilization of renewable energy sources for both domestics and industrial application
5. Analyze the environmental aspects of renewable energyresources.

Course Outcome:

1. Describetheenvironmentalaspectsofnon-conventionalenergyresources.
2. Know the need of renewable energy resources, historical and latestdevelopments.
3. Describe the use of solar energy and the various components used in the energy production with respect to applications like - heating, cooling, desalination, power generation, drying, cookingetc.
4. Appreciate the need of Wind Energy and the various components used in energy generation and know theclassifications.
5. Understand the concept of Biomass energy resources and their classification, types of biogas Plants- applications

Detailed Content:

UNIT-I

Solar Radiation:

Extra-terrestrial and terrestrial, radiation measuring instrument, radiation measurement and predictions. Solar thermal conversion: Basics, Flat plate collectors-liquid and air type. Theory of flat plate collectors, selective coating, advanced collectors, Concentrators: optical design of concentrators, solar water heater, solar dryers, solar stills, solar cooling and refrigeration. Solar photovoltaic: Principle of photovoltaic conversion of solar energy; Technology for fabrication of photovoltaic devices; Applications of solar cells in PV generation systems; Organic PV cells.

UNIT-II

Wind Energy:

Characteristics and measurement: Metrology of wind speed distribution, wind speed statistics,Weibull, Rayleigh and Normal distribution, Measurement of wind data, Energy estimation of wind regimes;

Wind Energy Conversion: Wind energy conversion principles; General introduction; Types and classification of WECS; Power, torque and speed characteristics; power curve of wind turbine, capacity factor, matching wind turbine with wind regimes; Application of windenergy.

UNIT-III

Production of biomass:

Photosynthesis-C3 & C4 plants on biomass production; Biomass resources assessment; Co2 fixation potential of biomass; Classification of biomass; Physicochemical characteristics of biomass as fuel Biomass conversion routes: biochemical, chemical and thermo chemical Biochemical conversion of biomass to energy: anaerobic digestion, biogas production mechanism, technology, types of digesters, design of biogas plants, installation, operation and maintenance of biogas plants, biogas plant manure-utilization and manure values. Biomass Gasification: Different types, power generation from gasification, cost benefit analysis of power generation bygasification.

UNIT-IV

Small Hydropower Systems:

Overview of micro, mini and small hydro system; hydrology; Elements of turbine; Assessment of hydro power; selection and design criteria of turbines; site selection and civil works; speed and voltage regulation; Investment issue load management and tariff collection; Distribution and marketing issues. Ocean Energy: Ocean energy resources, oceanenergy routs; Principle of ocean thermal energy conversion system, ocean thermal power plants. Principles of ocean wave energy and Tidal energyconversion.

UNIT-V Geothermal Energy:

Origin of geothermal resources, type of geothermal energy deposits, site selection geothermal power plants; Hydrogen Energy: Hydrogen as a source of energy, Hydrogen production and storage. Fuel Cells: Types of fuel cell, fuel cell system and sub-system, Principle of working, basicthermodynamics

Suggested Books:

1. Kothari, Singal&Rajan; Renewable Energy Sources and Emerging Technologies, PHILearn
2. Khan, B H, Non-Conventional Energy,TMH.
3. Sukhatme and Nayak, Solar Energy, Principles of Thermal Collection and Storage,TMH.
4. Tiwari and Ghosal, Renewable Energy Resources: basic principle & application,NarosaPubl
5. KoteswaraRao, Energy Resources, Conventional & Non-Conventional, BSPPublication.
6. Chetan Singh Solanki, Solar Photovoltaics: Fundamental, technologies and Application
7. AbbasiTanseem and Abbasi SA; Renewable Energy Sources; PHILearning
8. Ravindranath NH and Hall DO, Biomass, Energy and Environment, Oxford UniversityPress.
9. Duffie and Beckman, Solar Engineering of Thermal Process,Wiley
10. Nikolai, Khartchenko; Green Power; Tech BookInternational
11. Tester, Sustainable Energy-Choosing Among Options, PHILearning.
12. Godfrey Boyle, Renewable Energy: Power for a sustainable future, Oxford OUP.24