# BRANCH- PLASTIC ENGINEERING

***Specialization:*** **Plastic Engineering**

| Second Semester | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Theory | | | | Practical | | |
| **Course Name** | **Hours/ Week L/T** | **Credit Theory** | **University Marks** | **Internal Evaluation** | **Hours/ Week L/T** | **Credit Practical** | **Marks** |
| ***Specialization Core-1*** Properties & Testing of Plastics | 4-0 | 4 | 100 | 50 | - | - | - |
| ***Specialization Core-2*** Plastics Processing Theory and Product Design | 4-0 | 4 | 100 | 50 | - | - | - |
| ***Elective I(Specialization related)*** 1. Coating Science & Technology 2. Biodegradable Plastics 3 .Polymer Rheology 4. Plastics waste management and recycling. | 4-0 | 4 | 100 | 50 | - | - | - |
| ***Elective II (Departmental related)*** 1.Polymer degradation and stabilization . 2.Mechanical behavior of polymers 3.Polymer Blends and Alloys 4.Nylon technology | 4-0 | 4 | 100 | 50 | - | - | - |
| ***Elective III (from any department)*** 1.Production management 2.Engineering Economic and costing 3.Strength of materials 4.CAD/CAM/CAE application in mould/tool design | 4-0 | 4 | 100 | 50 | - | - | - |
| ***Lab-2 (Specialization lab to be decided by the department)*** | | | | | 4 | 4 | 150 |
| ***Seminar/Project*** | | | | | 4 | 4 | 150 |
| Total | | | | | | | |
| Total Marks: 1050 | | | | | | | |
| Total Credits: 28 | | | | | | | |

# PROPERTIES AND TESTING OF PLASTICS

**Module I**

Concepts of Testing & Identification Of Plastics Basic concepts of testing-Specification and Standards – National and International Standards – Test specimen preparation – Pre-conditioning and test atmosphere. Identification of plastics by simple test : Visual examination – Density – Melting point – Solubility test – Flame test – Chemical tests.

**Module II**

Physical Testing Long –term Mechanical Properties : Creep – Stress relaxation. Short-term Mechanical Properties : Tensile properties – Flexural properties – Compressive properties – Shear properties – Impact properties – Tear resistance – Hardness tests – abrasion resistance – Friction test. Gas and Moisture Permeability – Environmental stress cracking resistance – Crazing. Dielectric Strength – Dielectric Constant and dissipation factor – insulation resistance – volume and surface resistivity – Arc resistance – Antistatic tests. Refractive index – Luminous transmittance – Clarity and Haze – Photo –elastic properties – colour measurements and Specular Gloss.

**Module III**

Thermal Properties Melt flow index : Heat deflection temperature – Vicat softening temperature – Marten's Heat resistance test – Brittleness temperature – Specific Heat – Glass transition temperature – thermal conductivity – Co-efficient of thermal expansion – Shrinkage – Thermal stability – Flammability.

**Module IV**

Permanence Properties and Product Testing Water absorption : Chemical Resistance – UV resistance – Ozone resistance – weathering resistance – salt spray and straining resistance – Irradiation effects – Microbiological attack. Testing of pipes and fittings – films and sheets – container – Foam – Laminates and FRP based products – Failure Analysis.

**Text Book**

1. Vishu Shah, Hand Book of Plastics Testing Technology, John Wiley & Sons Inc. New York

2. R.P.Brown, Hand Book of Plastics Test Methods, George Godwin Ltd., London, 1981.

3. Analysis & Testing by Crompton.

4. J.S.Anand, K.Ramamurthy, K.Palanivelu how to identify Plastics by Simple Methods.

5. G.C.Lves, J.A.Mead, M.M.Riley, Hand Book of Plastics Test Methods, The Plastics Institute,

6. Frank T.Traceski, Specifications & Standards for Plastics & Composites, ASM International, Metals Park, OH, 1990.

7. J.Hasiam, H.A. Willis, Identification & Analysis of Plastics, London lliffe Books Ltd., New Jersy,

# PLASTICS PROCESSING THEORY AND PRODUCT DESIGN (3-1-0)

**Module I**

Injection Moulding : Introduction to microprocessor control systems, effect of processing parameters on moulding quality, frozen in stresses, Annealing, Processing of Engineering Plastics, Statistically process control.

**Module II**

Fabrication & decoration of plastics – Sealing, Welding, Joining, Printing, Painting, Host Stamping, Vacuum metalizing, In mould decoration.

**Module III**

Calendaring : Introduction, type of calendars, roll, configuration, definition of terms such as calendar bank, calendaring process, process variable and application.

**Module IV**

Concepts : Size, shape and function – form and function – Aesthetics, Ergonomics – Shrinkage, Flash lines, Undercuts – External & Internal – wall thickness – variance in wall thickness – suggested wall thickness for thermoplastics and thermosetting materials – steps in product design – emphasize on designing with engineering plastics – Taper or draft – Fits & Tolerance – Designing with plastics for load bearing applications like gear, bearing etc. Design of radii, fillets, ribs & bosses – Design for flow and shape – moulded holes – through hole – blind holes – threaded holes – side holes – holes parallel to draw – nearness of holes of each other and side wall – moulding holes not parallel to draw – drilled and tapped holes – moulded threads – moulded lettering – surface treatment.

**Text Books**

1. Donald V. Rossato, Injection Moulding Hanbook, International Thomson Publishing Co., 1995.

2. M.S.Welling, Injection Moulding Technology, VDI – Verlag Gmbh, 1981.

3. Seymour S.Sctiwartz & Sidney H.Goodman, Plastics Materials and process, Van Nostrand Reinhold Company, New York, 1982.

4. RGW PYE Injection Mould Design for Thermoplastics, affiliated East-West Press P. Ltd., New Delhi 1989.

5. Beck, Plastics product design, Yan Nostrand Reinhold Company London.

6. Donatas satas Plastics Finishing and Decoration Van Nostrand Reinhold Company, New York. 1986.

7. James M. Margoills, decorating Plastics, Hanset Publishers, New York, 1986.

# COATINGS SCIENCE & TECHNOLOGY

**Module I**

Basic paint technology ; Polymer binders, Pigments and extenders, additives.

**Module II**

Essential concepts of paint formulation and paint properties : pain preparation (pigment dispersion), surface preparation and paint application, paint properties and their evaluation, mechanism of film formation, factors affecting coating properties, methods used for film preparation and their properties; barrier properties and corrosion, mechanical properties, aging properties, rheological properties, adhesion properties and other related properties.

**Module III**

Mathematics of paint formulation, formulations of coating as finishes (automotive, appliance, coil, can, marine, aircraft etc.)

**Module IV**

State of the art technologies, specialty coating (radiation durable, nonpolluting, powder, high solids etc.)

**TEXT BOOKS**

1. Outline of paint technology, W.M. Morgans (3rd Edition – Recently CBS Publishers.

2. Paints, Coatings and Solvents, Dieter Stage (ED.) – 2nd Edition – Wernon Freitag Ltd., (Eds).

3. Principle & Paint Formulation, R. Woodbroidge (Ed.) – 1991.

# BIODEGRADABLE PLASTICS

**Module I**

Plastics & Environment, Degradation, Bio-degradation of Plastics.

**Module II**

Renewable resources, synthetic & natural plastics, Biodegradable starch based polymers, Microbial Polyamino acid, Lignum, Aliginate based cellulose / PLA / PHA Polyester, Polysaccharides, Chitens & chitosan etc.

**Module III**

Emerging applications areas: Coated Papers, Agricultural Mulch Film, Shopping Bags, Food Waste Film and Bags, Consumer Packing Materials, Landfill Cover Film, Other applications.

**Module IV**

Disposal Environments & Plastics Sorting and Reprocessing

Composing facilities and soil Burial, Anaerobic Digestion, Waste Water Treatment Plant, Reprocessing Facilities, Landfills, Marine and Freshwater Environments, Litter, Key Issues, Recyclable Plastics Sorting considerations, Reprocessing Considerations.

**Text Books**

1. G.J.L. Griffin, Chemistry and Technology of Biodegradable Polymers, Blackie Academic Professional, 1994.
2. Gerald Scott & Dan Gilad, Degradable Polymer – Principles & Applications, Chapman & Hall,
3. Y.Doi and K.Fukuda (Eds), Biodegradable Plastics and Polymers, Elsevier (1994)
4. Absorbabale & Biodegradable Polymers – S.N.Shalaby & K.J.L. Burg, CRC Press (2003).

# PLASTICS WASTE MANAGEMENT AND RECYCLING

**Module I**

Plastics Waste: Definition of plastics waste and the associated problems, Identification, collection methods and separation. Integrated waste management – source reduction, recycling, energy recovering process through thermal and biological destruction, Land filling and composting.

**Module II**

Recycling of plastics: Recycling and sustainability correlation, Basic principles and recovery, recycling and resource conservation. Recycling Technology.

**Module III**

Waste recycling and pollution control.

**Module IV**

Environmental issues, policies and legislation in India.

**Text Book**

1. R.J.Ehrig (Ed.), "Plastics Recycling – Products and Processes" Hanser Publication, Munich

2. Anthony L. Andrady (Ed.), " Plastics and the Environment:, Wiley Interscience, New York

3. Ministry Of Environments - Publications

4. R.J.Brandrup, "Recycling and recovery of Plastics", Hanser Publications, Munich (1996).

5. N.Mustafa, "Plastics Waste Managements, Disposal Recycling and Reuse, marcel Dekker, New York (1993).

# POLYMER DEGRADATION AND STABILISATION

**Unit I**

Introduction and Thermal Degradation: Definition - Modes of Polymer Degradation -Mechanistic Aspects - Single Step Process and Chain Reactions - Auto Oxidation - Random and Specific Site Attack - 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 (Cavitations 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 - 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 - Modes of Biological Degradation - Enzymatic Degradation in Bio Polymers (Polysaccharides, Proteins, Malice Acids) - Microbial Degradation of Synthetic Polymers -General Applications of Bio Degradable Plastics - Examples of Biodegradable Polyesters and Polyamides.

**Unit V**

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

**Reference Books:**

1 . W. Schnabel, Polymer Degradation - Principles and Practical Applications Hanser Publishers, New York, 1992.

2. Ann - Christine Albertsson , Samuel J. Huang , "Degradative Polymers Recycling and Plastic Waste Management" Marcel Dekker, New York, 1995.

3. Reich; Leo and Stivala; Salvatores, Elements of Polymer Degradation, McGraw-Hill Book Co., New York (1971).

4. Scott; Gerald and Gilead; Dan (Eds.), Degradable Polymers: Principles and Applications,Chapman and Hall, London (1995).

5. Bastioli, Catia (Ed.), Handbook of Biodegradable Polymers, Rapra Technology Ltd., Shawbury (2006).

# MECHANICAL BEHAVIOUR OF POLYMERS (3-1-0)

**Module I**

Elastic, viscoelastic and flow behavior of polymers, theory of linear viscoelasticity.

**Module II**

Creep and stress relaxations in polymers, super position principle and time-temperature equivalence.

**Module III**

Stress – strain behavior of polymers and the dependence of stress – strain curve on internal and external factors, plastic behavior of polymers, concept of forced elasticity and zarkov relation, fatigue and life time of polymers, fracture of polymers.

**Module IV**

Thermo mechanical behavior and analysis.

**Text Books :**

1. Compositional & Failure Analysis of Polymers John Scheoirs, John Willey & Sons Ltd.- 2000.

2. Mechanical Properties of Polymers & Composites by Nielson & Landel 2nd edition, Marcel Dekker Inc. 1994.

# POLYMER BLENDS AND ALLOYS

**Module I**

Definition, classification and importance of polymer blends and alloys, copolymer vs. polyblends and alloys; concept of polymer miscibility, thermodynamics of polyblends.

**Module II**

Interchain forces in polyblends, interpenetrating polymer network in polyblends, morphology and phase separation.

**Module III**

Preparation, processing and properties, characterization techniques rheology of polyblends and alloys.

**Module IV**

Applications of polyblends and alloys in adhesive, molded products, footwear, films, fibers, surface coating, miscellaneous uses, current trends in polyblends and alloys technology.

**Text Books :**

1. Polymer Blends & Alloys – An Overview,: RP Singh, CK Das, S.K.Mustafi, Asian Books Published 1st ed. 2002.

2. Polymer Blends & Alloys: Folkes & Hopes Blackie academic Professional 1993.

3. Advance in Polymer Blends & Alloys Technology by Malvyn Kohudic, Technomic, 1988.

4. L.A. Utracki, Commercial Polymer Blends, Chapman & Hall, London, 1998.

5. D.R.Paul & Seymour Newman, Polymer Blends, Vo. 1 & 2, Academic Press, New York, 1978.

6. Chris Rauwendaal, Polymer Mixing a self study guide, Hanser Publishers, Munich, 1998.

# NYLON TECHNOLOGY

**Unit I**

History -Development and commercial Nylons Polyamidation-Principle of Polyamidation-Process Technologies-hydrolytic polymerisation-Ionic Polymerisation, Solid phase polymerisation and other polymerisation techniques. Chemistry-Polymerisation and equilibria, Kinetic molecular mass, deformation of chemical attack.

**Unit II**

Physical structure: Structure properties relationship-crystallizing, melting temperature, to solubility, molecular weight, melt viscosity, degradation and stabilization, Electrical and mechanical properties. Characterisation: Identification, composition/moisture analysis, separation techniques, BGGmolecular mass and distribution, IR, NMR and X-ray diffraction.

**Unit III**

Fundamentals of Melt Processing: Measurements of viscosity, PVT relationships, importance of moisture, effect of molecular mass, shear, temperature, additives and channel shape. Applications of Rheological data to flow situation. Processing techniques of melt processing: Processing reagents, material handling and drying, injection moulding, extrusion, blow moulding and monomer processing.Other processing Techniques: Powder coating, blending and solution coatings. Secondary Treatments: Assembly, Moisture conditioning, mechanical surface clearing, and decorating.

**Unit IV**

Modification: Physical change- co-polymerisation-transparent nylons, filled and reinforced nylons, toughened nylons, fire retardant nylons, plasticized and lubricated nylons, additives for heat stabilization, processing and color and other modifications. Polymer Blends Alloys And Composites: Properties-factors affecting the properties of nylons, mechanical, thermal electrical and optical properties, moisture absorption, dimensional stability and density, environmental resistances and impact, flammability and failure analysis.

**Unit V**

Commercial Nylon Blends And Their Applications: PA6, PA66, PA46, PA6/2,PA11 &PA12 Raw materials- preparation –polymerisation- Methods of manufacturing, modifications, processing (methods, procedure processing parameters etc.,) Properties (material, tribological durability, water absorption dimension stability (immersion resistance, thermal/ electrical/optical properties, flammability resistance to permeation Applications)

**Reference Books:**

1. Malvin I. Kohan (ed.) Nylon plastics hand book, Hanser publisher, 1995.
2. Nicholar P. Chermisinof (ed.) Hand book of engineering Polymeric materials Marcel Dekker inc.N.Y. 19

# PRODUCTION MANAGEMENT

**Module – I (12 Hours)**

Productivity : Importance, Productivity ratio, Productivity measurement, Productivity Index, awareness – Improvement – maintenance (A.I.M) process. Production system : Models of production system, product Vs. Services, Process – focused & product focused systems, product strategies, product life cycle and production functions.Forecasting : Methods – Moving average, exponential smoothing, regression analysis, coefficient of co-relation, Delphi, Market Survey.

**Module – II (12 Hours)**

Facilities Planning : Site location, facilities layout, workplace design, working conditions – noise, illumination.Inventory Management EOQ models, safety stock and re-order level decisions, Distribution requirement planning, spare parts inventory control.

**Module – III (10 Hours)**

Motion study : Principles – economy, Time study – standard time.

**Module – IV (12 Hours)**

Production Planning & Control : aggregate planning, sequencing, Line balancing, Flow control, Dispatching, expediting, Gantt Chart, Line of balance, learning curve.

**Text Books :**

1. Riggs, J.L. Production Systems : Planning, Analysis & control John Wiley & Sons.

2. Buffa, E.S. & Sarin R.K.Modern Production / Operation Management, John Willey & Sons.

3. Chary, S.N. Production & Operations Management (TMH)

4. Muhelemann, Oakland & Lockyer, Production Operations Management, Macmillan.

# STRENGTH OF MATERIALS

**Unit – I**

Elasticity: Stress and strain, compressive, tensile, shear and bearing stress - Stress - strain diagram, Hooks law, modulus of elasticity, modulus of rigidity, bulk modulus of rigidity, bulk modulus, Poisson's ration. Relationship between elastic constraints and temperature stresses, composite bars, dead, live and shock loads.

**Unit – II**

Properties of section, calculation of areas, centroid, neutral axis, moment of inertia, modulus of section, radius of gyration with reference to structural shapes.

**Unit – III**

Theory of simple bends - relationship between load shearing force and bending moment. Bending moment and shear force diagram for cantilever, simple supported and over hanging beams - bending stresses. Deflection - deflection of beams in simple cases. Principal stresses and stains. Torsion in solid and hollow shafts - combined bending and torsion.

**Unit – IV**

Thin and thick cylinders and shells subjected to internal and external pressures.

**Unit – V**

Column and struts - long and short columns - axial and eccentric loading - effect of end conditions – equivalent length and slenderness ratio - Euler and Rankine formulae.

**References Books:**

1. R.S. Khurmi, Applied Mechanics and Strength of Materials S.Chand & Co., (6th ed), New Delhi,

2. P.N. Singh and I.K.Jha, Elementary Mechanics and Solids, Wiley Eastern, New Delhi.

3. Timoshenko, Strength of Materials

4. Singer, Strength of Materials

# CAD/CAM/CAE APPLICATION IN MOULD/TOOL DESIGN

**Module I**

Introduction – Basic Concepts of computer aided design – CAD and CADD system – shape and size description. Parametric programming – Construction of Engineering drawing – Two dimensional drafting – 3D surface and solid modeling – concepts of engineering data base-various techniques used to analyse the material properties.

**Module II**

Introduction to numerical control system – CNC machines – Types of control system for CNC machine – CNC processing – co-ordinate system – CNC axis and motion-CNC milling – CNC turning – CNC EDM – machining – CNC wire EDM concepts – concepts of CNC programme – tool motion – canned cycles – CNC interface with CAD-CNC stimulation software.

**Module III**

Computer integrated manufacturing (CIM) – computer aided design & manufacturing CAD/CAM process – advanced CAD/CAM Technology – Flexible Manufacturing System (FMS). Rapid prototyping – processor – Applications – Reverse Engineering - New generation cutting tools for mould manufacturing.

**Module IV**

Computer Aided Engineering (CAE) – Finite Element Analysis (FEA) – Flow analysis – Thermal analysis – Warpage Analysis – Cooling Analysis – Shrinkage Analysis – Pressure Analysis – C Mould – Mould Flow Analysis – Introduction and Application.

**Text Book:**

1. Frank Nanfara, Tony Uccello, Derek Murphy, “The CNC Work Book” on Introduction to Computer Numerical Control, Addison, Wesley Publishing Company, USA, 1995.

2. Ibrahim Zeid, CAD/CAM – Theory & Practice, Mc. Graw Hill, International Edition, 1998.