SEMESTER WISE COURSE STRUCTURE
& EVALUATION SCHEME

for

M. TECH. DEGREE PROGRAMME
IN
CHEMICAL TECHNOLOGY PLASTIC TECHNOLOGY
(Effective from the session 2020-21)

DEPARTMENT OF PLASTIC TECHNOLOGY
SCHOOL OF CHEMICAL TECHNOLOGY
HARCOURT BUTLER TECHNICAL UNIVERSITY
KANPUR-208002
UTTAR PRADESH

Department of Chemical Technology-Plastic Technology

Vision

"The department of chemical technology-plastic technology aspires to achieve excellence in technical knowledge and skill, research and innovation in Plastics and Allied areas"

Mission

The mission of the Department of Chemical Technology- Plastic Technology are:

- **M1 :** To develop state-of-the-art facilities to impart technical knowledge and skill to the graduate & post graduate students for plastic and allied industries and research organizations
- **M2 :** To be a center of research and innovation for betterment of society in sustainable manner.
- **M3 :** To develop state-of-the-art technologies for testing and consultancy for industry and society.
- **M4 :** To cultivate strong ethical values to be a successful professionals and to become life-long learners.

HARCOURT BULTER TECHNICAL UNIVERSITY KANPUR
SCHOOL OF CHEMICAL TECHNOLOGY
DEPARTMENT OF CHEMICAL TECHNOLOGY - PLASTIC TECHNOLOGY

Semester wise Course Structure

M. Tech. Chemical Technology - Plastic Technology
(Applicable from Session 2020-2021 for new entrants)

Year I, Semester I

(A Stream Only for students having B.Tech in Plastic Technology background)
(B Stream Only for students having B.Tech in other than Plastic Technology background)
(C Stream Only for students of M.Sc (Chemistry/Applied Chemistry /Industrial Chemistry) background)

Stream A

Sr. No.	Course Type	Subject Code	Course Title	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	PCC	TPL 551	Advanced Polymer Chemistry	5	3	1	2	15	20	15	50	50	100
2.	PCC	TPL 553	Advanced Polymer Processing	4	3	1	0	30	20	-	50	50	100
3.	PCC	TPL 555	Advances in Modelling and Simulation of Chemical Processes	4	3	1	0	30	20	-	50	50	100
4.	PEC	TPL 557	Advanced Chemical Reaction Engineering	4	3	1	0	30	20	-	50	50	100
		Total		**17**	**12**	**4**	**2**				**200**	**200**	**400**

OR

Stream B/C

Sr. No.	Course Type	Subject Code	Course Title	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	PCC	TPL 559	Advanced Polymer Rheology	4	3	1	0	30	20	-	50	50	100
2.	PCC	TPL 561	High Polymer Chemistry	5	3	1	2	15	20	15	50	50	100
3.	PCC	TPL 563	Polymer Processing	4	3	1	0	30	20	-	50	50	100
4.	PEC	TPL 567	Industrial Stoichiometery	4	3	1	0	30	20	-	50	50	100
5.	*MC (Non Credit)	BMA 551	Engineering Mathematics	2	2	0	0	-	-	-	-	-	-
		Total		**17**	**12**	**4**	**2**				**200**	**200**	**400**

*Only for students of Non-mathematics background at graduation level

HARCOURT BULTER TECHNICAL UNIVERSITY KANPUR
SCHOOL OF CHEMICAL TECHNOLOGY
DEPARTMENT OF CHEMICAL TECHNOLOGY - PLASTIC TECHNOLOGY

Semester wise Course Structure

M. Tech. Chemical Technology - Plastic Technology
(Applicable from Session 2020-2021 for new entrants)

Year I, Semester II

Sr. No.	Course Type	Subject Code	Course Title	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	PCC	TPL 552	Advanced Polymerization Engineering	4	3	1	0	30	20	-	50	50	100
2.	PCC	TPL 554	Advanced Plastic Product and Mould Design	4	3	1	0	30	20	-	50	50	100
3.	PCC	TPL 556	Polymer Testing and Characterization	5	3	1	2	15	20	15	50	50	100
4.	PEC	TPL 558 TPL 560	Advances in Polymer Composites Advances in Rubber Technology	4	3	1	0	30	20	-	50	50	100
5.	MC (Non Credit)	TPL 562	Audit Course Critical review of research publication on one relevant Topic		0	2	0						
6.	MC (Non Credit)	TPL 564	Audit Course Research Methodology and IPR		0	1	0						
		Total		**17**	**12**	**4**	**2**				**200**	**200**	**400**

HARCOURT BULTER TECHNICAL UNIVERSITY KANPUR
SCHOOL OF CHEMICAL TECHNOLOGY
DEPARTMENT OF CHEMICAL TECHNOLOGY - PLASTIC TECHNOLOGY

Semester wise Course Structure

M. Tech. Chemical Technology - Plastic Technology
(Applicable from Session 2021-2022)

Year II, Semester III

Sl. No.	Course Type	Subject Code	Course Title	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	PCC	TPL 651	Technology of Polymer Blends & Alloys	4	3	1	0	30	20	-	50	50	100
2.	PEC	TPL 653 TPL 655	Biodegradable Polymers, Packaging and Waste Management Polymer Nano Technology	4	3	1	0	30	20	-	50	50	100
3.	MC (Non Credit)	TPL 611	Audit Course Critical Review of Research Publications on one Relevant Topic		0	2	0						
4.	MC (Non Credit)	TPL 613	Audit Course Research Methodology and IPR		2	1	0						
5.	Seminar	TPL 697	Seminar	4	0	0	8	-	50	-	50	50	100
6.	Dissertation/ Project	TPL 695	*Dissertation/Project	2	0	0	4	-	50	-	50	50	100
		Total		**14**	**8**	**5**	**12**				**200**	**200**	**400**

*Dissertation to be continued in fourth semester.

HARCOURT BULTER TECHNICAL UNIVERSITY KANPUR
SCHOOL OF CHEMICAL TECHNOLOGY
DEPARTMENT OF CHEMICAL TECHNOLOGY - PLASTIC TECHNOLOGY

Semester wise Course Structure

M. Tech. Chemical Technology - Plastic Technology
(Applicable from Session 2021-2022)

Year II, Semester IV

Sl. No.	Course Type	Subject Code	Course Title	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	Dissertation/ Project	TPL 698	Dissertation/Project	12	0	0	24	-	50	-	50	50	100
		Total		**12**	**0**	**0**	**24**		**50**		**50**	**50**	**100**

I Semester

TPL 551 Advanced Polymer Chemistry

L	T	P	C
3	1	2	5

Syllabus

Unit 1: Synthesis by step-growth polymerizations

Systematic study of polymers with emphasis centered on those synthesized by step-growth polymerization and their kinetics such as - polyesters, polycarbonates, polyamides, epoxy, polyurethanes etc.

Unit 2: Synthesis by Ionic & Ring opening polymerizations

Systematic study of ionic polymers; Cationic and Anionic polymerisation. Mechanism of ionic polymerisation, effect of reaction conditions; Polymerization by ring opening polymerization and their kinetics such as ethers, lactones / lactams etc.

Unit 3: New and Complex catalytic polymerisations

Complex catalytic polymerisation, mechanism stereo specific polymerizations. Newer polymerization reactions such as ATRP polymerization and their applications.

Unit 4: Studies of Reaction kinetics

Reaction kinetics – rate equation – elementary, non-elementary reactions – mechanism –temperature dependence of reaction rates .Analysis of experimental reactor data – evaluation of reaction rates

Unit 5: Copolymerisation &polymer modifications

Copolymerisation reactions, effect of reactivity ratios on composition of copolymers, block and graft copolymers. Step copolymerization. Recent developments in polymer modifications, Microwave Synthesis.

Unit 6: Advanced Polymer Chemistry Lab

Synthesis of Addition polymer by advanced polymerization technique, synthesis of Epoxy resins having different epoxide equivalent weights, Microwave synthesis of polymers, new types of Emulsion polymerizations etc.

References

1. Text Book of Polymer Science, F.W.J. Billmeyer, John Wiley & Sons, 1984
2. High Polymer Chemistry in industry P. Tooley, J. murray 1971
3. Principle of Polymer Chemistry, P.J. Flory Cornell University Press, NY, 1953
4. Handbook of Polymer Synthesis, Part A & B, Hans. R. Kricheldorf, John Wiley & Sons 1991
5. Principles of Polymerization, Gorge Odeon, 2004
6. Introduction to Polymers, R.J. Young & P.A. Livell Ch. & Hall, London, 1981
7. Polymer Chemistry, Seymour & Caraher, Marcel Decker, 2003

TPL-553 Advanced Polymer Processing

L	T	P	C
3	1	0	4

Syllabus

Unit I: Extrusion Technology

Analysis of Extrusion process: basic flow pattern; melting mechanism; extruder and die characteristic diagrams; flow patterns of dies, different types of screw.

Plastic product formation by extrusion viz. film, pipe, lamination, sheet coating, profiles, wire and cable covering, granules, etc.: analysis of each process, associated problems and their remedies.

Casting process for films; Twin screw extruders and co-extrusion process

Reactive extrusion: basic principles, equipment used and applications. Process description of Calendaring process for plastic sheet forming, calendar roll arrangements, and their utility

Unit II: Injection Moulding Process

Analysis of injection moulding of thermoplastic and thermoset polymers, Principle and theory of screw plasticization and injection moulding operation; moulding cycle; Process variables; and their importance for machine cycle and quality of product. Analysis of moulding defects and their remedies, Gas assist and water assist injection moulding processes

Reaction injection moulding (RIM) Process, process parameters; process description and its utility for variety of products

Unit III: Moulding Process for hollow products

Type of blow Moulding processes and analysis of these with respect of process parameters viz. blow ratio, die shaping, parison control,; blow Moulding faults and their remedies. Stretch blow Moulding process. Various types of stretch blow Moulding operation: their description, process parameters, and utility of the process for variety of products like multi layered bottles

Rotational Moulding process: analysis of process parameters and utility of the process for variety of products

Thermoforming process details, various types of thermoforming methods. Thermoforming process variables affecting the product quality. Thermoforming faults and remedies. Thermoforming machines.

Unit IV: Moulding Processes for Thermoset polymers

Analysis of compression and transfer Moulding process, the description of various types of processes and their utility; process parameters; faults and remedies. Concept of Injection Moulding of thermoset polymers and process details. Process description and utility of hand layup, spray layup, pultrusion, filament winding, autoclave and bag Moulding techniques.

Unit V: Compounding and Finishing of Plastics

Compounding additives for plastics: their utility and affect on properties, Mixing process

Compounding equipments : mixers , blenders, mills, extruders, etc.

Finishing and decorative methods for plastics; Metalizing of plastics

Reference Books and Suggested Readings:

1. Plastics Extrusion Technology, by Allen Grief, Kriegn, Pub Co. 1976
2. Plastic Engineering Handbook (SPI), by J. Frados 1976, V N Reinhold. Joel Frades
3. Screw extrusion of Plastics, by H R Jacobi, 1963
4. Injection and Compression Moulding Fundamentals, by Isayev.
5. Encyclopedia of Polymer Science and Technology Vol. 1-23, by h F Mark & Overberger.

TPL 555 Advances in Modelling and Simulation of Chemical Processes

	L	T	P	C
Syllabus	**3**	**1**	**0**	**4**

Module1 (10 Lectures)

Fundamentals of mathematical modelling-Principles of formulations, Fundamental laws: Continuity equations, energy equation, equation of motion, transport equations, equation of state, equilibrium, chemical kinetics; Advantages and limitations of models and applications of process models of stand-alone unit operations and unit processes; Classification of models Simple vs. rigorous, lumped parameter vs. distributed parameter, Steady state vs. dynamic, Transport phenomena based vs. Statistical; Concept of degree of freedom for steady state and unsteady state systems.

Module 2 (8 Lectures)

Mathematical models of heat-transfer equipments: Double pipe heat exchanger, Shell & tube heat exchangers, Evaporators, Fired heaters, Partial condensers

Module 3 (6 Lectures)

Mathematical models of mass-transfer equipments: Batch and continuous distillation columns, Reactive distillation columns, packed absorption columns, Dehumidifiers

Module 4 (8 Lectures)

Mathematical models of reactors: Batch reactors, Continuous-stirred tank reactors, Plug-flow reactors, Industrial reactors-Ammonia converter, Sulphuric acid converter, Methanol reactor, FCC reactor, Claus reactor, etc.

Module 5 (8 Lectures)

Numerical methods: Linear and non-linear simultaneous algebraic equations, Ordinary differential equations-Initial-value problems & boundary-value problems, Partial-differential equations Different approaches to flow sheet simulation- Sequential modular approach, Simultaneous modular approach, Equation oriented approach; Review of thermodynamic procedures and physical property data banks.

Suggested Text Books:

1. Luyben, W.L., “Process Modeling, Simulation, and Control for Chemical Engineering”, Wiley.
2. M.M. Denn, “Process Modelling”, Wiley, New York, (1990).
3. Hussain Asghar, “Chemical Process Simulation”, Wiley Eastern Ltd., New Delhi, (1986)
4. C.D. Holland and A.I. Liapis, “Computer Methods for Solving Dynamic Separation Problems”, McGraw Hill, (1983).

Suggested Reference Books:

1. C.D. Holland, “Fundamentals of Modelling Separation Processes”, Prentice Hall, (1975)
2. S.M. Walas, “Modelling with Differential Equations in Chemical Engineering”, Butterworth, (1991)

TPL 557 Advanced Chemical Reaction Engineering

	L	T	P	C
Syllabus	**3**	**1**	**0**	**4**

Module 1 (6 Lectures)
Kinetics of heterogeneous catalytic reactions, rate equations, model discrimination and parameter estimation.

Module 2 (7 Lectures) Deactivating catalysts, mechanisms of catalyst deactivation, the rate and performance equations, design.

Module 3 (7 Lectures)

Mass Transfer and Reaction in a packed bed, Stoichiometric table, Pressure drop in a Reactor, Ergun's equation, Flow through a packed bed.

Module 4 (10 Lectures)

Types of multiphase reactors, mass transfer reactors, mass transfer equations, Interfacial surface area, mass transfer between phases, multiphase reactor equations, equilibrium between phases, membrane reactors, falling film reactors, bubble column reactors.

Module 5 (10 Lectures)

Falling film catalytic wall reactor, trickle bed reactors, multiphase reactors with catalysts, other multiphase reactors, reactor-separator integration, catalytic distillation, chromatographic reactors, iron ore refining, petroleum refinery.

Suggested Text Books

1. O. Levenspiel, "Chemical Reaction Engineering, Wiley India, (1998).

2. G. F. Froment and K. B. Bischoff, "Chemical Reactor Analysis and Design", John Wiley and Sons, (1979).

Reference Books

1. H. S. Fogler, "Elements of Chemical Reaction Engineering" 2nd edition, PrenticeHall, (2000).
2. Lanny D. Schmidt, "The Engineering of Chemical Reactions", 2nd edition, Oxford University Press, (2010).

TPL-559 Advanced Polymer Rheology

L	T	P	C
3	1	0	4

Syllabus

Module -I: Basic Rheological Concept

Polymer flow, the ideal elastic response, pure viscous flow, new tonian and non - Newtonian flow, pseudo plastic, bingham, dilatant and thixotropic behaviour.

Module-II: Mechanical Models

Origin of non-Newtonian flow, Factors influencing flow behaviour, Viscoelasticity, mechanical models for linear viscoelastic response, Maxwell and Voigt models, generalized voight element.

Module – III: Rheological Principles and Dynamic Properties

Superposition principles: Boltzmann superposition, time-temperature superposition, WLF equation, shift factor, definition for storage and loss modulus, loss tangent and complex modulus, fatigue.

Module-IV: Viscosity of Polymer Melts, Rheometers and Viscometers

Viscosity of polymer melts – die- swell and melt fracture – Weissenberg effect – Elongational viscosity. Measurements of rheological properties – capillary rheometers – cone and plate viscometer – torque rheometers – Mooney viscometer.

Module-V: Application of Rheological Studies on Polymer Processing

Fiber-polymer interaction, filler geometry, volume fraction filler surface, wettability, filler surface treatment, rheology, effect of polymer matrix, steady shear viscosity data.Application of rheological studies in polymer processing such as injection moulding, extrusion and blow moulding.

References

1. Plastic Engineering, Pergamon, Crowford.R.

2. Flow properties of polymer melts-Godwin, Brydson, JA.

3. Polymer melt rheology-Godwin, Cogswell, F.N., 1981

4. Applied Fluid Rheology, J. Ferguson & Z. Kemblowski

5. Introduction to Polymer Viscoelasticity, J.J. Aklonis& W.J. Macmight

TPL 561 High Polymer Chemistry

L	T	P	C
3	1	2	5

Syllabus

Unit 1: Introduction to polymers

Introduction to polymer, polymer classifications based on occurrence, types, process, and end uses, concept of macromolecules and their molecular weights, polymer physical state, application of polymers.

Unit 2: Step polymerizations

Introduction to step polymerization, kinetics of step polymerization, self-catalyzed polymerization, external catalysis of polymerization, molecular weight control in linear polymerization, molecular weight distribution in linear polymerization, crosslinking reactions, molecular weight distributions in nonlinear polymerizations.

Unit 3: Addition polymerizations

Kinetics and mechanism of free radical, initiation mechanisms, molecular weights and its distribution of free radical polymer, chain transfer reactions, inhibition and retardation, effect of temperature and pressure on polymerization, Autoacceleration, living free radical polymerization, cationic, anionic and living polymerization.

Unit 4: Coordination polymerizations

Coordination polymerization, properties of stereo regular polymers, traditional Ziegler–Natta polymerization of nonpolar alkene monomers, propagation at carbon–transition metal bond, mechanism of isoselective and syndio selective propagation, effects of components of Ziegler–Natta initiator, kinetics, metallocene polymerization of nonpolar alkene monomers, commercial applications.

Unit 5: Copolymerization Reactions

Chain copolymerization and its general considerations, copolymer composition, radical copolymerization, types of copolymerization behavior, variation of copolymer composition with conversion, effect of reaction conditions, applications of copolymerization, ring-opening polymerization-general characteristics and applications.

Unit 6: Advance Polymerization lab

Synthesis of Addition polymer by advanced polymerization technique, synthesis of Epoxy resins having different epoxide equivalent weights, Microwave synthesis of polymers, new types of Emulsion polymerizations, etc.

References

1. Text Book of Polymer Science, F.W.J. Billmeyer, John Wiley & Sons, 1984
2. high Polymer (His chemistry in industry P. Tooley, J. murray 1971
3. Principle of Polymer Chemistry, P.J. Flory Cornell University Press, NY, 1953
4. Handbook of Polymer Synthesis, Part A & B, Hans. R. Kricheldorf, John Wiley & Sons 1991
5. Principles of Polymerization, Gorge Odeon, 2004
6. Introduction to Polymers, R.J. Young & P.A. Livell Ch. & Hall, London, 1981
7. Polymer Chemistry, Seymour & Caraher, Marcel Decker, 2003

TPL-563 Polymer Processing

L	T	P	C
3	1	0	4

Syllabus

Unit I: Extrusion Technology

Fundamentals of Polymer Processing; Concepts of Extrusion process for plastics- basic operation and analysis, melting mechanism, components of extruder, Overall extruder performance, die and screw Characteristics curves. Different types of screw. Extrusion process for production of viz. film, pipe, amination, sheet coating, profiles, wire and cable covering, granules, etc. Concept of twin screw extruders and co-extrusion process; Casting process for films; Concept of Calendaring process for plastic sheet forming, calendar roll arrangements, application of Calendaring process

Unit II: Injection Moulding Process

Basic concepts of injection Moulding of thermoplastics Principle and theory of standard injection Moulding operation, Moulding cycle, Process variables, temperature, pressure, injection rate, etc and their importance for machine cycle and quality of product. Faults and remedies in Injection Moulding Operation. Concept of reaction injection Moulding (RIM) Process, process parameters; process description and its utility for variety of products

Unit III: Moulding Process for hollow products

General description of blow moulding processes, type of blow Moulding machines, blow Moulding faults and their remedies. Stretch blow Moulding process. Concepts of stretching temperature, transparency, etc. various types of stretch blow Moulding operation Rotational Moulding process description and features of rotational Moulding machines. Process variables in rotational Moulding process. Concepts of thermoforming process and various means of forming. Description of various thermoforming methods. Thermoforming machines.

Unit IV: Moulding Processes for Thermoset polymers

Concept of Injection Moulding of thermoset polymers and process details. General concept of compression and transfer Moulding process, the description of various types of compression and transfer Moulding processes and their utility in processing of thermosetting materials Concept of hand layup, spray layup, pultrusion, filament winding, autoclave and bag Moulding techniques.

Unit V: Compounding and Finishing of Plastics

Concept of compounding of polymers; utility and types of compounding additives viz. fillers, plasticizers, colorants, stabilizers, blowing agents, flame-retardants, antioxidants, etc. Mixing, blending and compounding equipments, finishing of Plastics.

Reference Books and Suggested Readings:

1. Plastics Extrusion, by Allen Grief
2. Plastic Engineering Handbook (SPI), by Frados
3. Screw extrusion of Plastics, by Jacobi
4. Injection and Compression Moulding Fundamentals, by Isayev.
5. Encyclopedia of Polymer Science and Technology Vol. 1-23, by Mark &Overberger.
6. HandBook of Injection Moulding, by Rosato&Rosato.
7. Practical Thermoforming Principles & Applications, by J. Florian.

TPL 567 Industrial Stoichiometry

L	T	P	C
3	1	0	4

Syllabus

Module 1

Dimensions, system of units and their conversions, Mass and volume relations, Basic stoichiometric principles, limiting and excess reactants, Degree of completion, Conversion, selectivity, yield. Ideal gas law, Dalton's Law, Amagat's Law, Introduction to degrees of freedom analysis.

Module 2

Vapor pressure of liquids and solids, Vapor pressure plot (Cox chart), Vapor pressures of miscible and immiscible liquids and solutions, Raoult's Law and Henry's Law. Humidity and saturation, Use of humidity charts for engineering calculations.

Module 3

Material balance without chemical reactions and its application to unit operations like distillation, etc. Material balance with chemical reaction Recycle, bypass and purging.

Module 4

Heat capacity of gases, liquids and solutions, Heat of fusion and vaporization. Steady state energy balance for systems with and without chemical reactions. Calculations and application of heat of reaction combustion, formation, neutralization and solution. Enthalpy-concentration charts. Orsat analysis Calculation of theoretical and actual flame temperatures

Module 5

Simultaneous material and energy balance. Introduction to Unsteady state material and energy balance.

Suggested Text books

1. Hougen, O.A., Watson, K.M and Ragatz, R.A., " Chemical Process Principles Part-I ",John Wiley and Asia Publishing, 1970.
2. Himmelblau, D.M., "Basic Principles and Calculations in Chemical Engineering" ,sixth Edition, Prentice Hall Inc., 1996.
3. Felder, R.M. & Rousseau, R.W. "Elementary Principles of Chemical Processes ", 3rd edition. JohnWiley. (1999)
4. Bhatt, B.L., VORA, S.M., "Stoichiomentry ", Tata McGraw-Hill, 1976.
5. Venkataramani, V., Anantharaman, N., Begum, K. M. MeeraSheriffa, "ProcessCalculations" , Second Edition, Prentice Hall of India.
6. Sikdar, D. C., "Chemical Process Calculations", Prentice Hall of India.

II Semester

TPL-552 Advanced Polymerization Engineering

L	T	P	C
3	1	0	4

Syllabus

Unit 1: Basics of Industrial polymerization

Industrial methods of polymerization, such as bulk, solution, suspension, slurry, gas phase and emulsion and their recent developments .Layout and arrangement of polymer plants, reactor types and processes.

Unit 2: Manufacturing of Commodity Plastics

Manufacturing of various polyolefins, such as LDPE, HDPE, LLDPE, PP and copolymeric grades, production technology, properties and application of commodity plastics as PVC, PS and its copolymers.

Unit 3 Manufacturing of Engineering Plastics

General characteristics of engineering plastics , chemistry of synthesis, manufacturing process, properties and application of common engineering plastics such as ABS, polycarbonate, polyamide, PMMA, polyesters.

Unit 4: Manufacturing of Thermosetting Plastics

Manufacturing details, properties and application of various thermosetting resins, such as phenol formaldehyde, urea formaldehyde, melamine formaldehyde, epoxy, preparation of moulding powders.

Unit 5 : Manufacturing of Speciality Plastics

Manufacturing details, properties and application of fluorine containing polymers, polyacetals, polyphenylenesulphide, and polyphenylene oxide .

References

1. Plastic Materials, J.A. Brydson
2. Polymer Production, Mayo & Smith
3. Macromolecular Synthesis, J A Moore
4. Handbook of Plastic Technology, M. Chandha
5. Handbook of Thermoplastics, Olagoke Olabisi
6. Plastic Materials and Processes, C. Harper
7. Material Science of Polymer of Engineers F A Osscoald & G menges, Plastic Tech. Handbooks J F engg. Ramirez

TPL-554 Advanced Plastic Product and Mould Design

L	T	P	C
3	1	0	4

Syllabus

Unit 1: Product specifications and Design

Product specifications; Material and Process selection. Tooling Aspects on Product Design – Product Design Appraisal; and Tolerances on Product. Product design criteria–Geometric ,Structural, Environmental, Assembly, Aesthetics & Decoration. Product design check list, Safety in product design.

Unit 2: Product Design Guidelines for structural Features

Shrinkage, Wall thickness – variations in wall thickness – suggested wall thickness for various plastics materials – Tapers or draft angles. – Design of radii, fillets, ribs and bosses. Undercuts –Types and moulding. Moulded Holes –Types and moulding considerations, Moulded threads and Inserts.

Unit 3: Injection Mould Design Basics

Basic construction of mould – Types of moulds: Mould plates, spruebush, locating ring, core and cavity, Guide pillar & guide bush, etc. Bolsters, Mould clamping methods, Feed System: Sprue, Runner & Gate ; cross section and size of runner –runner layout – balancing of runners ; types of gates for various materials – cross section of gate .

Unit 4: Advanced Injection Mould Design

Types of ejector grid – Ejector plate Assembly; Guiding & Supporting, Types of ejection – position & critical area of ejection; Mould cooling – Integer type cavity and core plates cooling, etc. Two Plate and Three Plate Mould Designs, Split moulds; External undercuts &Splits.

Unit 5: CAD & other type moulds/Dies

Design concepts of Compression, Transfer and Blow moulds. Extruder Die Design basics, Computer Aided Mould Design, Use of Simulation software like Mould Flow .Good design practices; cycle time and profitability in Mould Design.

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References

1. Plastics Product Design, Beck R.D.
2. Plastic Part Design Hand book- Rosato&Rosato
3. Injection Mould Design – Pye R.G.W
4. Extrusion Die Design – Joshi, M.V.
5. Plastic MouldEngieering Hand Book, - J. H. Dubois & W.I.Pribble
6. Dies for Plastic Extrusion, - M. V. Joshi

TPL-506 Polymer Testing and Characterization

L	T	P	C
3	1	2	5

Syllabus

Module I: Testing and Quality Control of Polymers

Testing of polymer properties-thermal, optical, electrical and mechanical properties as per standard specifications-ASTM, BS, ISI, ISO and their importance, correlation to these tests with actual performance, preparation of test pieces and conditioning. Importance of specifications and standards in quality control of polymers and polymer products.

Module II: Introduction to Polymer Characterization by Instrumental Techniques

Introduction to polymer characterization by instrumental techniques such as TGA, DTA, DSC, TMA, XRD, IR, NMR, MALDI-TOF, GC-MS, GPC, UV-visible spectroscopy.Polymer surface and interface characterization by SEM, TEM, AFM and optical microscopy.

Module III: Mechanical Properties

Tensile, compressive and flexural response, stress strain behaviour, models, cold drawing, strain hardening, effect of temperature, plasticizer and additives on mechanical properties, brittleness abrasion resistance hardness tests – incandescence resistance, ignition properties, oxygen index,s urface burning characteristics.

Module IV: Electrical and Optical Properties

Electrical properties – insulation resistance –power factor – permittivity - dielectric strength –tracking resistance – arc resistance and antistatic test. optical properties: refractive index, luminous transmittance, haze, density, water absorption, moisture analysis.

Module V: Chemical Properties

Crush and burst strength. chemical resistance –environmental stress cracking resistance – ageing – gas permeability – water vapour permeability and weathering.

Module VI: Testing and Characterization Lab

Experiments related to tensile test, impact test, flexural strength, melt flow index, UV visible spectrophotometer, Differential scanning calorimetric (DSC) Analysis, Thermogravimetric Analysis (TGA).

References

1. Fundamentals of Plastic Testing, Springer,S. K. Nayak, S. N. Yadav, S. Mohanty
2. Plastics Engineering Hand book - by Society of the Plastic Industry Inc
3. Practical Polymer Analysis, J. Shiers
4. Polymer Characterization (ACS), C.D. Craver
5. Handbook of Plastic Testing Technology, Brown and Shah
6. Handbook of Plastics Test Method, R.B. Brown

TPL-558 Advances in Polymer Composites

L	T	P	C
3	1	0	4

Syllabus

Unit 1: Introduction and Additves of Composites

Introduction –Advantages; Characteristic properties of polymer Composites, Classification of Composites: particulate, fibrous, laminated, and hybrid composites, Additives for Composites: Catalysts, Accelerators, Toughening Agents; Concept of interface between polymer and reinforcements and coupling agents; theory of reinforcement, concept of alignment of fibers and its effect on properties of composites

Unit 2: Materials for Polymer Composites

Properties and Applications of matrix materials for polymer composites; thermoset resins: Unsaturated Polyester resin, Vinyl Ester resin, Epoxy resins, Phenol Formaldehyde resin, Urea Formaldehyde resin, Melamine Formaldehyde Resin, Thermoplastics: ABS, Nylon, Polycarbonate, PET,PBT,PEEK, Polyimides, Polysuphones, etc.; Rubbers Reinforcement materials: Fibre Reinforcements: types and forms , Performs - Woven and Non Woven Fabrics of Glassfibre, Carbon fibre, Aramid Fibre, Boron Fibres, Natural Fibres

Unit 3: Processing of Composites

Description, utilty and impoertant parameters of various processing techniques like Hand and Spray Layup, RTM, Bag Moulding, Autoclave Moulding, Centrifugal and Compression Moulding; Filament Winding, Pultrusion, Sandwich Construction, concept of DMC, SMC, BMC, TMC

Unit 4: Testing and quality Control of Polymer Composites

Testing methods and standards for mechanical, electrical, thermal, optical, and chemical proprties of polymer composites, Non destructive testing; compressive testing, intra laminar shear testing, inter laminar shear testing, fracture testing etc. Determination of shelf life and gel time of composites, environmental effects on composites.

Unit 5: Polymer Composites for specific applications

Propellant binders: Classification of propellants- solid, liquid, hybrid and air breathing. Solid propellants– homogenous smokeless propellants, Heterogeneous (composite) propellants. Sandwitch panels for military and space applications**,** CNT based composites**,** nanocomposites, Adhesively bonded joints and mechanically fastened joints,

References

1. Hand Book of Composites, by George Lubin
2. Hand Book of Fibre glass and Advanced Plastic Composites, by G. Lubin
3. Reinforced Thermoplastics, by W.V. Titov
4. Engineering Design for Plastics, by Eric Baer
5. Glass Engineering Hand Book, by E.S. Shend
6. Plastics and Composites welding Handbook by Grewell, Benatar& Park
7. Polymer and composite Rheology by R. K. Gupta
8. Reinforced Plastic Handbook by Rosato&Rosato
9. High Performance Thermosets, Chemistry, Properties and Applications, S.C Lin, E.M. Pearce, HanserPublictions, 1994
10. Engineered Materials Handbook vol 3 Adhesives and sealants, Vol.3, C.A. Dostaletal, ASM International, 1990

TPL-560 Advances in Rubber Technology

L	T	P	C
3	1	0	4

Syllabus

Unit 1: Introduction and Compounding of Rubber

Characteristic properties of rubber and elastomers, significance of structure and important features of elastomers. General effect on Properties-Evaluation and functions of additives – Antioxidants, Stabilizers, carbon black-its types, manufacture and characteristics- mechanism of reinforcement of a rubber, non black fillers in rubbers, Plasticizers, Impact Modifiers ,Lubricants, Antistatic agents, Anti blocking agents, processing aids, Blowing agents, Flame Retardants, Master batch Colorants, Nucleating agents.

Unit 2: Natural rubber

Production of different grades of natural rubber from latex, modified natural rubber and its derivatives. Application of latex, technically specified rubber, chemistry of vulcanization and various vulcanization techniques, role of accelerators and activators and effect of vulcanization techniques on cross link density and properties of rubber

Unit 3: Synthetic Rubbers

Polymerization techniques involved in production of general purpose synthetic rubbers like SBR, Polybutadiene, EPDM; heat resistant synthetic rubbers like butyl rubber, silicone rubber, polysulphide rubbers, fluorine containing rubbers, and solvent resistant synthetic rubbers like polychloroprene rubbers, nitrile rubbers, hypalon, etc.; polyurethane rubbers, their vulcanization, properties and applications, speciality and modified rubbers, thermoplastic elastomers

Unit 4: Processing of Rubbers

Compounding techniques and mechanism of mixing and dispersion, stabilization, coagulation, etc. Machinery used for mixing, two roll mill, internal mixers and continuous mixers, extrusion technology, calendering and different types of calenders.

Moulding: Compression, transfer and injection moulding, different methods of vulcanization such as rotocure, autoclave open steam, high energy radiation, etc.

Unit 5: Rubber Product Manufacture

Manufacturing methods for the products like rubber tyres – design and construction, reinforcing system, building and curing of various types of tyres; conveyor and transmission beltings; hoses and tubings; wire and cables coating; rubber to metal bonded articles; mechanical seals, cellular products, shoe soles; manufacture of latex products like foam, dipped goods, latex thread, etc.

Reference Books and Suggested Readings:

1. Rubber Technology & Manufacture, by C.M.Blow
2. Encyclopedia of Polymer Science and Technology Vol. 1-23, by Mark &Overberger
3. Rubber Technology, by Maurice Morton
4. Synthetic Rubbers, by D.C. Blacklay
5. Handbook of Elastomers – New Developments & Technology, Anil .K. Bhowmic, Howard L. Stephens (Edt), Marcel Decker Inc. New York 1988.
6. Natural Rubber Handbook - R. R. I. I. Kottayam

III Semester

TPL 651 Technology of Polymer Blends and Alloys

L	T	P	C
3	1	0	4

Syllabus

Unit1 Introduction

Definition for Blends and Alloys; Reason and advantages of Blending, Selection criteria of blending polymers and designing of blends; Classification of Polymer Blends; Miscible Blends and Immiscible Blends, Methods of blending: Melt blending, solution blending, Latex blending, powder blending,

UNIT II Polymer/polymer miscibility

Concept of immiscibility and miscibility of polymers; Phase Equilibria Calculation; Huggins - Flory Theory; Factors Affecting Miscibility of Polymer Blends, concept of Compatibility; composition of blends, Solubility Parameter; Interaction Parameter. Determination of miscibility by measurements of Refractive Index, Ultrasonic Velocity, Thermal and Optical Methods; transition temperature; molecular weight.

UNIT III Thermodynamics, crystallization and melting of polymer blends

Introduction to Thermodynamic Principles of blending; Thermodynamics of a Single Component Systems; Polymeric Liquid mixtures; Theory of liquid mixtures; Phase Separation of polymers in blends; Methods of Measurements; Crystallization, Morphological and Melting Behavior of Polymer Blends

UNIT IV C**ompatibilized blends and methods of toughening**

Concept of compatibility; Types and Role of Compatibilizer; Methods of Compatibilization; Mechanism of Compatibilization; Properties of Compatibilized Blends; Mechanism and Theory of Toughing; Toughening of Thermoplastics

UNIT V Rheology and applications of polymer blends and alloys

Introduction to Rheology of Miscible and Immiscible Blends; Rheological models for miscible and immiscible polymer blends and alloys

Applications polymer blends and alloys in Automotive, Electrical and Electronics, Medical, Packaging, building and construction, Business machines and communication

References

1. L. A. Utracki, Polymer blends and alloys, Hanser Publishers, New York, 1979
2. L. A. Utracki, Polymer Blends Hand book, Kluwer academic publishers, UK, 2002
3. L. M. Robeson, Polymer blends Hanser publications, USA, 2007
4. M. J. Folkes, P. S. Hope, Polymer blends and alloys, Springer, London, 2012

TPL 653 Biodegradable Polymers, Packaging and Waste Management

	L	T	P	C
Syllabus	**3**	**1**	**0**	**4**

Unit 1: Biodegradable Polymers

Biodegradable polymers - polycaprolactone- modified polycaprolactone copolymer with ester, amide and urethane linkages, polyglycolate, polymandelic acid. Polyhydroxyalkanoate, Various Types of PHA, Mechanisms of PHA Biosynthesis, Starch-Based Technology, Poly(Lactic Acid) and Copolyesters, polyglutamic acid. Applications in agriculture, medicine, packaging. Introduction to Bio-based Polymers.

Unit 2: Biodegradation and Biodegradability of Polymers

Biodegradation -introduction–modes of biological degradation–enzymatic degradation of biopolymers and synthetic polymers - microbial degradation of synthetic polymers. Biodegradability of Polymers – Mechanisms and Evaluation Methods, Mechanisms of Polymer Degradation, Measuring Biodegradation of Polymers, Factors Affecting Biodegradability

Unit 3: Biodegradable Polymers used for Packaging

Major polymers used for packaging- Evaluation of the following polymers for packaging Applications- polyethylene , EVA, EAA, LDPE ,HDPE, LLDPE, metallocene polymer, PP,PVC, PVDC, PS, PVOH, EVOH, nylon, polyester, polycarbonate, fluoro polymers, ABS, acrylonitrile

Unit 4 : Processing and Testing of Packaging Polymers

Methods of processing of packaging adhesives, heat sealing types, sealing method, extrusion blown film and cast film and sheet co-extrusion, surface treatment testing and evaluation of films, flexible packaging, pouches, bulk and heavy duty bags, thermoforming, thin sheet thermoforming, blow moulding, extrusion and injection blow moulding, foams, cushioning and distribution packaging thermoplastic

Unit 5: Disposal of Solid Municipal Waste

Disposal of solid municipal waste by biodegradation – composting(bioreactors)- deposition in landfills – microbial decomposition processes in anaerobic rubbish dumps. Ideal bioreactors –stirred tank reactor – batch and continuous operations – Fed - Batch operation - plug flow reactor, Concept of carbon footprint

References

1. Gordon.L Robertson, Food Packaging, Taylor and Francis (2006)
2. G.J.L. Griffin, Chemistry and Technology of Biodegradable Polymers,
3. Gerald Scatt& Dan Gilad, Degradable Polymers – Principles & Applications
4. Catia Bastioli, Handbook of Biodegradable Polymers

TPL 655 Polymer Nano Technology

L	T	P	C
3	1	0	4

Syllabus

Unit I Introduction to Nano Technology

Introduction to scientific revolutions-time and length scale in structures; – nano, micro and macro scales, Definition of nanosystem; Dimensionality and size dependent phenomenon, surface to volume ratio, fraction of surface atoms, surface energy, surface stress, surface defects, properties of materials at nanoscale

Unit II Nano fillers for polymer composites

Concept of quantum dots, wells and wires, classification of nano materials, carbon based nano materials like bulky balls, Carbon nanotubes- single walled and multi walled- preparation, treatment and functionalization, grapheme, etc.; Nanoclay-Dispersion and nucleating effects, intercalation and exfoliation. Application of layered and nonlayered nano and micro particles in polymer modification; Metal based nano materials (nanogold, nanosilver and metal oxides); Production and purification of nano fillers; Characterization of nano fillers

Unit III Polymer nanocomposites and nanopolymers

Synthesis of Polymer Nanocomposite: Direct Mixing, Solution Mixing, In-Situ Polymerization, In-Situ Particle Processing of Ceramic/Polymer Composites, In-Situ Particle Processing Metal/Polymer Nanocomposites, Modification of Interfaces, Modification of Nanotubes, Modification of Nanoparticles. Surface treatment, Composites manufacturing techniques. Processing of polymer nano composites
Polymerization techniques for synthesis of nano polymers, properties and application of nanopolymers;

Unit IV Characterization of Polymer nanocomposites and nanopolymers

Thermal, mechanical and electrical properties- tribological characteristics, fracture behavior, creep and fatigue behaviour, composite material rheology. Long term effects, applications of composites. Characterization of Polymer Nanocomposites and nano fillers: Particle Size Analysis, Glass Transition and Relaxation, X-ray Diffraction, Scanning Electron Microscopy, Transmission Electron Microscopy, Small-Angle X-Ray Scattering (SAXS), Cone Calorimetry (CC) and Mass Loss Calorimetry (MLC).

Unit V Application of Polymer nano composites and nano polymers

Synthesis and modification of polymer nano composites for specific applications and their utility; nano composites containing functionalized nanoparticles: Organic and polymer materials for electronics devices such as LED, Photo-voltaics, etc., Polymer Nano composites for Bio-medical application, Photo-oxidation of polymers, Nano particles approaches to enhance the lifetime of polymers. Biodegradable polymer nano composites

References

1. Liming Dai, 'Carbon Nanotechnology'
2. Joseph H. Koo, Polymer Nano composites, Processing, Characterization, and Applications, McGraw-Hill 2006
3. L.A. Utracki " Clay-Containing Polymeric Nano composites" Rapra Technology Limited, 2004
4. Luigi Nicolis& Gianfranco Carotenuto "Metal -Polymers Nano compsites" A John Wiley & Sons, Inc Publication 2005
5. P. M. Ajayan, L. S. Schadler, P. V. Braun (Eds) Nanocomposite Science and Technology WILEY-VCH Verlag GmbH Co. KGaA, Weinheim, 2003
6. C. Ke& P. Stroeve " Polymer-Layered Silicate and Silica Nano composites- Elsevier, 2005
7. Polymer nano composites: Synthesis characterization and modeling, R. Krishnamoorti and R.A. Vaia (Americal Chemical Society, 2002)
8. Polymer Clay Nano composites, Pinnavaia T.J. and Beall G.W. (John Wiley 2000)

TPL 695 SEMINAR

L	T	P	C
0	0	8	4

In the seminar, power point presentation shall be prepared on polymer oriented and advanced topics with references of journal papers. Presentation is to be planned for duration of 15 minutes including a question answer session of five minutes. The marks will be awarded based on the relevance and knowledge content; language and way of presentation of the seminar.

TPL 697 DISSERTATION/ PROJECT WORK

L	T	P	C
0	0	4	2

The students shall be undertaking a research project for a period of 1 year either in a leading Industry/research Institution or in the department. The research work will be guided by one supervisor from the respective industry /Institution and one supervisor from the department .The student will have to submit an interim report at the end of third semester and give a presentation in the Department. The evaluation will be made based on the thesis, the presentation and the viva voce as per university guidelines. The report may include the aspects of the literature review, identification of problem, PET chart and work done. A comprehensive oral Viva-voce examination will be conducted to assess the student's, depth of understanding of problem.

IV Semester

TPL 698 DISSERTATION/ PROJECT WORK	L	T	P	C
	0	0	24	12

The students shall be continuing the research project guided by one supervisor from the respective industry /Institution and one supervisor from the department .The student will have to submit final thesis at the end of fourth semester and give a presentation in the Department. The final evaluation will be made based on the thesis, the presentation and the viva voce as per university guidelines. The thesis shall include the report of third semester, methodology of work and findings in proper format. A comprehensive oral Viva-voce examination will be conducted to assess the student's depth of understanding in the specified field and findings of his work, etc. An internal and external examiner shall be appointed by the University for the Conduction of viva voce under University examination System.

References for online courses

MOOC Courses references

1. **Thermodynamics of materials** - https://www.edx.org/course/thermodynamics-of-materials-2

https://www.edx.org/course/thermodynamics

2. **Transport Phenomenon** - https://www.edx.org/course/analysis-of-transport-phenomena-i-mathematical-met

NPTEL Courses references

1.**Processing of Polymers & Polymer Composites** - https://nptel.ac.in/courses/112/107/112107221/

2. **Introduction to Composites** - https://nptel.ac.in/courses/112/104/112104229/

3. **Introduction to Polymer Science** - https://nptel.ac.in/courses/104/105/104105124/

4. **Polymer Chemistry** - https://nptel.ac.in/courses/104/105/104105039/

5. **Science & Technology of Polymers** - https://nptel.ac.in/courses/113/105/113105028/