ANNA UNIVERSITY:: CHENNAI 600 025
AFFILIATED INSTITUTIONS
M.TECH. PLASTICS TECHNOLOGY
REGULATIONS – 2017
CHOICE BASED CREDIT SYSTEM

PROGRAMMEEDUCATIONAL OBJECTIVES (PEOs)

I. To provide an interdisciplinary specialization in master degree with emphasis on materials, engineering and fundamentals of polymers and their processing and to produce employable post graduates with knowledge and competency in scientific and engineering aspects of polymers, plastics, additives and compounding.

II. To impart the concepts of synthetic resins, composites, engineering plastics, adhesives and conducting polymers and their applications in industries and to providethe overall knowledge on mould manufacturing, characterisation, quality control and recycling through theory and practical.

III. To gain knowledge on biodegradable polymers, thermoplastics elastomers and fibres in engineering applications and to provide comprehensive knowledge on plastics testing, composite product design and plastic waste management.

PROGRAMME OUTCOMES (POs)

1. **Engineering Knowledge**: To select and apply the knowledge, techniques, skills and modern tools of plastics technology to broadly define. To apply and integrate knowledge from four elements i.e., polymer structure, properties, process and performance to solve the industrial problems and also to develop an entrepreneur skill.

2. **Problem Analysis**: To choose and apply the knowledge of mathematics, science, engineering and technology to polymers and plastics technology problems that requires the application of principles and applied procedures or methodologies. To impart knowledge of the topics of inter-disciplinary research, problem identification, formulation and solution in plastics technology.
3. **Design/development of solutions**: To conduct standard tests and measurements to analyze and interpret the experimental results for improving the processes.
4. **Conduct investigations of complex Problems**: To design systems, components or processes for broadly defined plastics technology problems.
5. **Modern Tool Usage**: To use the techniques, skills and modern engineering tools necessary for engineering practice to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability.
6. **The Engineer and Society**: To understand the need and engage in self-directed continuing professional development. Learn future technologies through acquired foundation skills and knowledge and employ them in industry and business environments
7. **Environment and Sustainability:** To understand the impact of Plastics technology solutions in a societal and global context.
8. **Ethics:** To demonstrate an understanding of and a commitment to professional and ethical responsibilities, including a respect for diversity.

9. **Individual and team work**: To function effectively as a member or leader on a technical team. Professionally skilled for higher studies in research institutions and to work in plastics industries.
10. **Communication:** To communicate effectively regarding broadly defined Plastics technology activities.
11. **Project Management and Finance**: To Demonstrate knowledge and understanding of engineering and management principles and apply to polymer engineering work
12. **Life-long learning:** exhibit a commitment to quality, timeliness and continuous improvement.

PEO/PO Mapping

PEO	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
I	✓	✓	-	-	-	✓	-	-	-	✓	-	-
II	✓	✓	✓	-	✓	-	-	-	-	-	-	✓
III	-	-	✓	-	✓	-	✓	✓	-	-	-	-

PO MAPPING

YEAR	SEM	Course Title	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
YEAR 1	I	Mathematics for Plastics Technology	-	✓	✓	✓	-	-	-	-	-	-	✓	-
		Plastics Materials	✓	-	-	-	-	-	✓	-	-	✓	✓	-
		Additives and Compounding	✓	-	-	✓	-	-	✓	-	-	-	-	-
		Plastics Testing Technology I	✓	-	✓	-	-	-	✓	-	✓	-	-	✓
		Plastics Processing Laboratory I	✓	✓	-	-	✓	✓	-	-	-	-	-	-
		Plastics Testing Laboratory I	✓	-	✓	-	✓	-	✓	-	-	-	-	✓
		Polymer Synthesis and Characterization Laboratory	✓	-	✓	-	-	✓	-	-	✓	✓	✓	-
	II	Plastics Testing Technology II	✓	✓	-	-	-	-	✓	-	✓	-	-	✓
		Polymer Composites Engineering	✓	-	✓	-	-	✓	✓	-	-	-	-	-
		Mould Manufacturing Technology	-	-	✓	-	✓	-	-	-	✓	-	-	-
		Blending of Polymers	✓	-	-	-	✓	✓	✓	-	✓	✓	-	-
		Plastics Processing Laboratory II	✓	✓	-	-	✓	✓	-	-	-	-	✓	✓
		Plastics Products/Tool Design Laboratory	✓	-	✓	✓	✓	-	-	-	-	-	✓	✓
		Plastics Testing Laboratory II	✓	-	✓	-	✓	-	✓	-	-	-		✓
YEAR 2	III													
		Project Work (Phase-I)	✓	-	✓	-	-	✓	-	-	-	✓	✓	-
	IV	**Project Work (Phase-II)**	✓	-	✓	-	-	✓	-	-	-	✓	✓	-

ELECTIVE														
YEAR	**SEM**	**CourseTitle**	**PO**	**PO**	**PO**	**PO**	**PO**	**PO**	**PO**	**PO**	**PO**	**PO**	**PO**	**PO**
YEAR1	I	Advanced Plastics Processing Technology	✓	✓	✓	✓	✓	✓	-	-	-	-	✓	-
		Plastics Packaging Technology	✓	-	-	-	✓	✓	✓	-	✓	-	-	✓
		Coating Science and Technology	✓	✓	-	-	✓	-	✓	-	-	-	-	✓
	II	Plastics Mould and Product Design	-	-	✓	✓	✓	-	-	-	-	-	✓	-
		CAD/CAM/CAE Appln. In Mould/Tool Design	-	✓	✓	-	✓	✓	-	-	-	-	✓	-
		Research Methodology	-	✓	✓	✓	✓	-	✓	-	✓	-	-	✓
		Plastics Characterization Techniques	✓	-	✓	-	-	✓	✓	✓	-	-	-	✓
		Physics and Rheology of Polymers	✓	-	-	-	✓		✓	-	-	-	-	✓
		Polymers for Advanced Applications	✓	✓	-	-	-	✓	-	-	-	-	-	-
YEAR2	SEMIII	Polymer Nano composites	✓	-	-	✓	-	✓	✓	-	-	-	✓	-
		Thermoplastic Elastomers	✓	-	-	✓	-	✓	✓	-	-	-	✓	-
		Secondary Processing Techniques	✓	✓	✓	✓	-	-	-	-	-	-	-	-
		Additive Manufacturing in Plastics Products	✓	-	-	-	✓	✓	✓	-	-	-	✓	-
		BioPolymers and Biocomposites	✓	-	-	✓	-	✓	✓	-	-	-	✓	-
		Polymer Recycling	✓	-	-	✓	-	✓	✓	-	-	-	✓	-
		Advanced Mould Manufacturing Technology	-	-	✓	-	✓	-	-	-	✓	-	-	-
		Total Quality Management	-	✓	✓	✓	-	-	-	-	-	-	✓	-
		Bio-Medical Plastics	✓	-	-	✓	-	✓	✓	-	-	-	✓	-
		Intellectual Property Rights and Copyright Laws	-	-	✓	-	-	✓	-	✓	-	-	✓	-
		Industrial Economics and Costing	-	✓	-	-	-	✓	-	-	✓	-	✓	✓

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I TO IV SEMESTERS CURRICULUM AND SYLLABUS

SEMESTER I

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	MA5163	Mathematics for Plastics Technology	FC	4	4	0	0	4
2.	PA5101	Plastics Materials	PC	3	3	0	0	3
3.	PA5102	Additives and Compounding	PC	3	3	0	0	3
4.	PA5103	Plastics Testing Technology I	PC	3	3	0	0	3
5.		Professional Elective I	PE	3	3	0	0	3
PRACTICAL								
6.	PA5111	Plastics Processing Laboratory I	PC	4	0	0	4	2
7.	PA5112	Plastics Testing Laboratory I	PC	4	0	0	4	2
8.	PA5113	Polymer Synthesis and Characterization Laboratory	PC	4	0	0	4	2
			TOTAL	**28**	**16**	**0**	**12**	**22**

SEMESTER II

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	PA5201	Plastics Testing Technology II	PC	3	3	0	0	3
2.	PA5202	Polymer Composites Engineering	PC	3	3	0	0	3
3.	PA5203	Mould Manufacturing Technology	PC	3	3	0	0	3
4.	PA5204	Blending of Polymers	PC	3	3	0	0	3
5.		Professional Elective II	PE	3	3	0	0	3
6.		Professional Elective III	PE	3	3	0	0	3
PRACTICAL								
7.	PA5211	Plastics Processing Laboratory II	PC	4	0	0	4	2
8.	PA5212	Plastics Products / Tool Design Laboratory	PC	4	0	0	4	2
9.	PA5213	Plastics Testing Laboratory II	PC	4	0	0	4	2
			TOTAL	**30**	**18**	**0**	**12**	**24**

SEMESTER III

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.		Professional Elective IV	PE	3	3	0	0	3
2.		Professional Elective V	PE	3	3	0	0	3
3.		Professional Elective VI	PE	3	3	0	0	3
PRACTICAL								
4.	PA5311	Seminar	EEC	4	0	0	4	2
5.	PA5312	Project work (Phase I)	EEC	12	0	0	12	6
			TOTAL	**25**	**9**	**0**	**16**	**17**

SEMESTER IV

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
PRACTICAL								
1.	PA5411	Project Work (Phase II)	EEC	24	0	0	24	12
			TOTAL	**24**	**0**	**0**	**24**	**12**

TOTAL CREDITS: 75

LIST OF ELECTIVES

SEMESTER I, PROFESSIONAL ELECTIVE I

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	PA5001	Advanced Plastics Processing Technology	PE	3	3	0	0	3
2	PA5002	Plastics Packaging Technology	PE	3	3	0	0	3
3	PA5003	Coating Science and Technology	PE	3	3	0	0	3

SEMESTER II, PROFESSIONAL ELECTIVE II

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	PA5004	Plastics Mould and Product Design	PE	3	3	0	0	3
2	PA5005	CAD/CAM/CAE Application in Mould / Tool Design	PE	3	3	0	0	3
3	PO5091	Research Methodology	PE	3	3	0	0	3

SEMESTER II, PROFESSIONAL ELECTIVE III

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	PA5006	Plastics Characterization Techniques	PE	3	3	0	0	3
2	PA5007	Physics and Rheology of Polymers	PE	3	3	0	0	3
3	PA5008	Polymers for Advanced Applications	PE	3	3	0	0	3

SEMESTER III, PROFESSIONAL ELECTIVE IV

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	PO5071	Thermoplastic Elastomers	PE	3	3	0	0	3
2	PO5072	Polymer Nanocomposites	PE	3	3	0	0	3
3	PA5009	Secondary Processing Techniques	PE	3	3	0	0	3
4	PA5010	Additive Manufacturing in Plastics Products	PE	3	3	0	0	3

SEMESTER III, PROFESSIONAL ELECTIVE V

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	PA5011	Bio Polymers and Bio composites	PE	3	3	0	0	3
2	PA5071	Polymer Recycling	PE	3	3	0	0	3
3	PA5012	Advanced Mould Manufacturing Technology	PE	3	3	0	0	3

SEMESTER III, PROFESSIONAL ELECTIVE VI

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	PA5072	Total Quality Management	PE	3	3	0	0	3
2	PA5013	Bio-Medical Plastics	PE	3	3	0	0	3
3	PO5073	Intellectual Property Rights and Copyright Laws	PE	3	3	0	0	3
4	PA5014	Industrial Economics and Costing	PE	3	3	0	0	3

FOUNDATION COURSE (FC)

S.No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	MA5163	Mathematics for Plastics Technologist	FC	4	4	0	0	4

PROFESSIONAL CORE (PC)

S. No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	PA5101	Plastics Materials	PC	3	3	0	0	3
2.	PA5102	Additives and Compounding	PC	3	3	0	0	3
3.	PA5103	Plastics Testing Technology I	PC	3	3	0	0	3

4.	PA5111	Plastics Processing Laboratory I	PC	4	0	0	4	2
5.	PA5112	Plastics Testing Laboratory I	PC	4	0	0	4	2
6.	PA5113	Polymer Synthesis and Characterization Laboratory	PC	4	0	0	4	2
7.	PA5201	Plastics Testing Technology II	PC	3	3	0	0	3
8.	PA5202	Polymer Composites Engineering	PC	3	3	0	0	3
9.	PA5203	Mould Manufacturing Technology	PC	3	3	0	0	3
10	PA5204	Blending of Polymers	PC	3	3	0	0	3
11	PA5211	Plastics Processing Laboratory II	PC	4	0	0	4	2
12	PA5212	Plastics Products / Tool Design Laboratory	PC	4	0	0	4	2
13	PA5213	Plastics Testing Laboratory II	PC	4	0	0	4	2

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	PA5311	Seminar	EEC	4	0	0	4	2
2.	PA5312	Project work (Phase I)	EEC	12	0	0	12	6
3.	PA5411	Project Work (Phase II)	EEC	24	0	0	24	12

MA5163 MATHEMATICS FOR PLASTIC TECHNOLOGY L T P C
4 0 0 4

OBJECTIVES :

- This course is designed to provide a solid foundation on topics in probability, various numerical and statistical methods which form the basis for many other areas in the mathematical sciences including statistics, modern optimization methods and risk modeling. It is framed to address the issues and the principles behind the numerical solution of differential equations, probability, statistics, testing of hypothesis and queuing models. This will also serve as a precursor for future research.

UNIT I NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS 12

Solution of first order ordinary differential equation - Taylor's method - Euler's method - Runge - Kutta method of fourth order - Predictor – Corrector Methods - Milne's and Adam's – Bashforth methods - Introduction to numeric use of the above techniques in plastics engineering and calculations.

UNIT II NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS 12

Classification of second order linear partial differential equations - Elliptic equations – Solution of Laplace equations – Solution of Poisson's equation - Parabolic equations – Solution of one - dimensional heat equation - Hyperbolic equations – Solution of wave equation.

UNIT III PROBABILITY AND STATISTICS 12

Probability – Addition theorem - Multiplication theorem - Conditional probability – Baye's theorem - Distribution functions - Binomial distribution - Poisson distribution - Normal distribution - Uniform distribution - Curve fitting – Fitting a straight line and second degree curve - Fitting a non linear curve - Correlation and regression.

UNIT IV QUEUEING MODELS 12

Poisson process – Markovian queues – Single and multiserver models – Little's formula – Steady state analysis – Self service queue.

UNIT V TESTING OF HYPOTHESIS 12

Sampling distribution – Large sample and small samples - Testing of null hypothesis - Type I and Type II errors - "t" test and Chi square test - Goodness of fit - Fisher's "F" test.

TOTAL : 60 PERIODS

OUTCOMES :

After completing this course, students should demonstrate competency in the following skills:

- Theories and methods in solving both Ordinary Differential and Partial Differential Equations numerically
- Basic probability axioms and rules and the moments of discrete and continuous random variables.
- Distributions and its properties, correlation, regression.
- Use statistical tests in testing hypotheses on data.
- Exposing the basic characteristic features of a queuing system and acquire skills in analyzing queuing models.

The students should have the ability to use the appropriate and relevant, fundamental and applied mathematical and statistical knowledge, methodologies and modern computational tools.

REFERENCES :

1. Burden, R. C. and Faires, J. D., "Numerical Analysis", 9th Edition, Cengage Learning, 2016.
2. Johnson, R.A., Miller, I and Freund J., "Miller and Freund's Probability and Statistics for Engineers", Pearson Education, Asia, 8th Edition, 2015.
3. Gupta, S. C. and Kapoor, Y. K., "Fundamentals of Mathematical Statistics", Sultan Chand and Sons, 1994.
4. Gross, D., Shortle, J.F., Thomson, J. M. and Harris, C. M., "Fundamentals of Queuing Theory ", 4th Edition, Wiley, 2014.

PA5101 PLASTICS MATERIALS L T P C

3 0 0 3

OBJECTIVES

- To understand the mechanism of polymerization, techniques of polymerization and the significance of different molecular weight averages.
- To provide in depth knowledge about different kinds of plastic materials based on their structure and properties
- To make the student familiar about properties and end application of different plastics materials

UNIT I POLYMER CHEMISTRY 9

Introduction to polymer–Polymerization–Chain polymerization –Step polymerization. Polymerization techniques–Bulk polymerization – Solution polymerization –Suspension polymerization– Emulsion Polymerization. Molecular weight and its distribution.

UNIT II COMMODITY PLASTICS 9

Sources and Manufacture of raw materials - Methods of manufacture of Polymer, General Properties and applications of Polyethylene - Polypropylene and their copolymers-Vinyl Polymers and Co-polymers-Polystyrene and Copolymers-Acrylic and copolymers-Cellulose Polymers.

UNIT III ENGINEERING PLASTICS 9

Sources and Manufacture of raw materials, Methods of Manufacture of Polymer, General Properties and applications of Acrylonitrile Butadiene Styrene -Polyamides (PA-6,PA- 66,PA-6,10,PA-11&12)- Polycarbonates- Polyacetal& Copolymers- Thermoplastic Polyesters (PET&PBT)-Polyphenyleneoxide-Polysulfones- Fluoropolymers (PVF,PVDF,PTFE,PCTFE) – Thermoplastic Polyurethane.

UNIT IV SPECIALITY PLASTICS 9

Sources and Manufacture of raw materials, Methods of manufacture of Polymer, General properties and applications of Polyphenylene Sulphide-Polyphenylene ether Polyetherether ketone – Polyimide and related polymers-Liquid Crystal Polymers- Conductive Polymers– Plastic alloys and blends.

UNIT V THERMO SETTING PLASTICS 9

Sources and Manufacture of raw materials, Methods of manufacture of resin-Additives – Curing and cross linking agents-General properties and applications of Phenol Formaldehyde - Urea Formaldehyde - Melamine Formaldehyde – Unsaturated Polyesters-Epoxyresins-PolyurethaneandSilicones. OverviewofRecycling -Recycling of Polymers-Overview of plastics degradation – NaturalBio-degradablePolymers-SyntheticBio-degradablePolymers-Watersoluble Polymers.

TOTAL : 45 PERIODS

OUTCOMES

At the end of the course, the student should be able to

- Apply suitable polymerisation technique to prepare the plastics as per the requirement.
- Select the plastic materials for particular end use based on properties.
- Predict the behaviour of different kinds of plastics material based on their structure and property relationship.

REFERENCES

1. Charles A.Harper, Modern Plastics Hand Book,McGraw-Hill,NewYork,1999.
2. Fred W. Billmeyer, JR., Text Book of Polymer Science, John Wiley &Sons,Singapore,1994.
3. H.Domininghaus,PlasticsforEngineers,HanserPublishers,Munich-1988.
4. J.A.Brydson,PlasticsMaterials,ButterworthHeinemannOxford,1999.
5. J.S.Anand,ApplicationsofPlastics,CIPET,Chennai-1997.
6. NabilMustafa,PlasticsWasteManagement,MarcelDekkerInc.,NewYork,1993.

PA5102 ADDITIVES AND COMPOUNDING L T P C

3 0 0 3

OBJECTIVES

- To know about various additives like Lubricants, Fillers, Fibres, flame retardants, colourants, anti-oxidants, UV-stabilizers, plasticizers, anti-blocking agents, Nucleating agents, Flow promoters, Anti static agents etc.
- To understand the functions of each of these additives, technical requirements, types & mechanism, and their effective evaluation are dealt with in this subject.
- To select suitable plastics material compounding and mixing techniques like two roll milling, internal blender, single / twin screw extruder, etc.

UNIT I INTRODUCTION TO ADDITIVES 9

Introduction-Technological Requirements – Classification-Chemistry and Mechanism-Selection Criteria-General effect on Properties-Evaluation and functions of additives.

UNIT II ADDITIVES 9

Antioxidants-Stabilizers(Heat&UV)-Plasticizers-Fillers and reinforcements-Impact Modifiers-Lubricants – Slip and Anti-block agents – Processing aids – Blowing agents-Flame Retardants – Anti – static &Conductive additives – Nucleating agents – Colorants –Additives for Recycling.

UNIT III COMPOUNDING TECHNIQUES 9

Selection of Polymers and Compounding ingredients-General objectives-possibilities and limitations of mixing and compounding-Methods of incorporation of additives into polymer materials.

UNIT IV COMPOUNDING EQUIPMENTS 9

Mixing and mixing equipment's. Principles- Operating characteristics- Machine construction-Specifications -Process control systems and working details of Batch mixers and continuous mixers –High speed mixer -Two roll mill-Banbury Mixer–Ribbon blender – Planetary mixers-Single Screw extruder-Twin Screw extruder.

UNIT V END USE MARKET FOR PLASTICS 9

Principles of Material selection including consideration of conventional materials competitive with plastics - Case studies on material suitability (e.g., Plastic Gears, Feeding Bottle, Bowels for micro wave ovens). Survey and uses of plastics with reasons for their importance in major industries like, Agriculture, Packaging, Building, Transport, Electrical, Electronics and Telecommunications, Medical and Furniture.

TOTAL : 45 PERIODS

OUTCOMES

At the end of the course, the student should be able to

- Select the suitable additive as per requirement.
- Identify the suitable compounding techniques to make different grades of Plastics compounds
- Formulate the compound to solve the environmental related problems.

TEXTBOOKS

1. Murphy; John, Additives for Plastics Handbook, 2nd Edition, Elsevier Advanced Technology, Oxford.
2. Al – Malaika; S. Golovoy; A and Wilkie (Eds), Chemistry and Technology of Polymer Additives, Black well Science Ltd, Oxford (1999).
3. Matthews; F.L. and Rawlings; R.D, Composite Materials, Engineering and Science Chairman and Hall, London (1994).

REFERENCES

1. IcaManas – Zloczower and ZehevTadmor, Mixing and Compounding of Polymers, HanserPublications,Munich,1995.
2. J.A.Brydson, Plastics Materials, Butterworth Heinemann, Oxford,1999.
3. Jesse Edenbaum, Plastics Additives and Modifiers Hand Book, Chapman &Hall, London,1996.
4. Mascia; L.,The Role of Additives in Plastics, Edward Arnold Publishers Ltd., U. K. (1974).
5. Nicholas P. Cheremision off, Polymer Mixing and Extrusion Technology, Marcel Dekker Inc.,New York,1995.
6. R. Gachter and H. Muller, Plastics Additives Hand Book, Hanser Publishers, Munich,1993.

PA5103 PLASTICS TESTING TECHNOLOGY I L T P C

3 0 0 3

OBJECTIVE

- To develop the knowledge of National & International standards for testing methods.
- To create the knowledge about the different testing techniques and its basic concepts for evaluating the chemical, mechanical, electrical, optical, thermal, and permanence properties of plastic materials.
- To enable the students to identify and compare the properties of different plastics materials.
- To enable the students to learn about the property of the plastic material for several applications.

UNIT I **9**

Consideration of importance of testing for identification of plastics-Determination of necessary manufacturing conditions-Assessment of properties of finished products in relation to service requirements.

UNIT II **9**

Standard and specifications - National and International standards-BIS, ASTM, ISO & NABL.

UNIT III **9**

Identification of common plastics materials by simple tests e.g., visual inspection, density, effects of heat, combustion and solvents, analysis with common solvents.

UNIT IV **9**

Preconditioning and test atmosphere - Testing of Mechanical properties. Thermal properties., Optical properties.

UNIT V **9**

Testing of Electrical properties, Permeability Properties and Rheological properties.

TOTAL : 45 PERIODS

OUTCOME

Upon completion of this course,

- Ability to test the plastics materials for its chemical, mechanical, electrical, optical, thermal, and permanence properties as per the standard.
- Ability to identify the plastic materials by reverse engineering for some specified applications with the knowledge of testing.

REFERENCES

1. Allen; W.S and Baker; P.N, Hand Book of Plastics Technology, Volume 2, Identification
2. Testing & Recycling of Plastics, CBS Publishers and distributors, New Delhi 2004).
3. Brown; Roger P (Ed.), Hand Book of Polymer Testing, Marcel Dekker, Inc, New York
4. Brown; Paul F (Ed), Hand Book of Plastics Test Methods, Longman Scientific and Technical, Harlow (1988).
5. Shah, Vishnu, Hand Book of Plastics Testing Technology, John Wiley and Sons, SPE Monograph (1984).
6. Blythe; A. R., Electrical Properties of Polymers, Cambridge University Press, Cambridge

PA5111 PLASTICS PROCESSING LABORATORY I **L T P C**
0 0 4 2

OBJECTIVE

- To gain practical knowledge about hand operated injection moulding, semi automatic & automatic injection moulding machine, Blow moulding process.
- To identify defect, causes & remedies of the process.
- To select the suitable process parameters for a particular process.

EXPERIMENTS

1. Injection Moulding (Hand Operated)
2. Injection Moulding (Semi -Automatic)
3. Injection Moulding (Automatic)

4. Extrusion Processes
5. Compression Moulding (Hand Operated)
6. Compression Moulding (Semi Automatic)
7. Blow Moulding (Hand Operated)
8. Scrap Grinding

LABORATORYREQUIREMENTS

1. Injection moulding machine (conventional) - 2Nos.
2. Plastic tube extrusion machine - 1No.
3. Plastic film extrusion machine - 1No.
4. Compression moulding machine - 1No.
5. Blow moulding machine(conventional) - 1No.
6. Scrap grinding machine - 1No.

TOTAL : 60 PERIODS

OUTCOME

- Understand all the manufacturing techniques, machine components, their function and setting of process parameter.
- Analyze the cycle time and process parameter to overcome the trouble shoots.

REFERENCES

1. A.S.Athaly, Injection Moulding Practice, Multi-Tech. Publishing Co., NewDelhi, 1997.
2. Friedhelm Hensen, Plastics Extrusion Technology, Hansar Publishers, Vienna, 1988.
3. Irvin Rubin, Injection Moulding Theory and Practice, A.Wileyinterscience
4. Lee, Blow Moulding Design Guide,HausarPublishers,Munich,1998. Publication.1972.

PA5112 PLASTICS TESTING LABORATORY I L T P C
0 0 4 2

OBJECTIVE

- To create the knowledge and in hand practice for operating the injection moulding and Compression moulding machine to prepare specimens for various testing of plastics materials as per the ASTM standards.
- To prepare sheet specimens by Contour cutting & Punching
- To get practice in testing the Physico-mechanical properties of plastic materials.
- To learn about the compounding of plastics materials.

EXPERIMENTS

Chemical Lab: Identification of Plastics – Viscosity and Molecular Weight Determination – Determination of K-value for PVC.

Demonstration: Melting point – Carbon black content – Filler content – Environmental stress cracking resistance – PH meter – Hooper Viscometer – Brookfield Viscometer.

Specimen Preparation Lab: Specimen preparation using injection moulding machine – Compression moulding machine – Two roll mill and Contour cutter.

Demonstration: Scrap grinder – Blender11

Physio-Mechanical Lab: Tensile strength – Flexural strength – Compression strength – Tear strength - Impact strength – Hardness

Demonstration: Abrasion resistant tester – Folding endurance tester – Burst strengthtester – Density gradient column – Creep tester – Moisture vapour transmission rate –Gas permeability – Sieve analysis.

TOTAL : 60 PERIODS

OUTCOME

- Ability to prepare specimen through injection & Compression moulding and by contour cutting & punching with the shape & size as per ASTM standards for various testing of Plastics Materials.
- Ability to test the Chemical & Mechanical properties of plastics materials in the laboratory.
- Ability to select suitable compounding equipment as per the requirement.

LABORATORY REQUIREMENTS

Chemical Laboratory

1. Viscometer - 1 No.
2. Melting point apparatus - 1 No.
3. Carbon black content tester - 1 No.
4. Environmental stress cracking resistance tester - 1 No.
5. Brookfield viscometer - 1 No.
6. PH meter - 1 No.

Specimen Preparation Laboratory

1. Injection moulding machine - 1 No.
2. Compression moulding machine - 1 Nos.
3. Two roll mill - 1 No.
4. Contour cutter - 1 No.
5. Scrap grinder - 1 No.
6. Blender - 1 No.
7. **Physio-mechanical Laboratory**
8. Universal testing machine - 1 Nos.
9. Tear strength tester - 1 No.
10. Impact strength tester - 1 Nos.
11. Shore A – Hardness tester - 1 No.
12. Shore D – Hardness tester - 1 No.
13. Rockwell Hardness tester - 1 No.
14. Abrasion resistance tester - 1 No.
15. Folding endurance tester - 1 No.
16. Burst strength tester - 1 No.

Humidity chamber - 1 No.

17. Gas permeability tester - 1 No.
18. Sieve analysis apparatus - 1 No.

REFERENCES

1. ASTM test standards for plastics Vol.8.01 to 8.04, 9.01 & 9.02, 2002.
2. ISO test standards, 1998.
3. R.P. Brown, Hand Book of Plastics Test Methods, George Godwin Ltd., London,1981.
4. Vishu Shah, Hand Book of Plastics Testing Technology, John Wiley & Sons. Inc.New York, 1998.

PA5113 POLYMER SYNTHESIS AND CHARACTERISATION LABORATORY

L T P C
0 0 4 2

OBJECTIVES

- To provide hands on experience on various polymerization techniques.
- To make the student understand simple experimental procedures to determine molecular weight and molecular weight distribution of polymers.
- To make the student familiarize with the thermal properties of polymers.
- To make the student understand simple techniques to identify the plastic materials.

LIST OF EXPERIMENTS

1. Identification of Plastics materials.
2. Density determination.
3. Bulk polymerization - Preparation of polymethyl methacrylate.
4. Solution Polymerization - Preparation of polyacrylamide.
5. Preparation of Phenol-Formaldehyde, UF and MF resins.
6. To study auto acceleration by solution polymerization method.
7. Synthesis of copolymers by Emulsion, Bulk, solution &suspension Polymerization.
8. Measurement of viscosity of polymer solutions and determination of molecular weight of the polymer.
9. End group analysis.
10. Determination of acid value of a resin.
11. Study of Molecular weight distribution (GPC).
12. Determination of cure of a phenolic moulding (percentage acetone soluble matter).
13. Study of Thermal Stability of polymers.

TOTAL : 60 PERIODS

OUTCOMES

1. Ability to measure viscosity of polymer solutions.
2. Ability to synthesize various types of polymers by using suitable polymerisation techniques.
3. Capability to identify plastics materials by simple methods.

Equipment required:

glassware for reactions and spot tests, Ostwald/Ubbelhode viscometer, TGA, DSC

PA5201 PLASTICS TESTING TECHNOLOGY II

L T P C
3 0 0 3

OBJECTIVE

- To develop knowledge of National & International standards for testing methods.
- To create the knowledge about the conditioning of samples and samplepreparation techniques for testing various properties of plastics materials.
- To enable the students to learn about the evaluation of thermal, electrical, opticaland mechanical properties of plastics materials.
- To create knowledge about testing of plastics products as per the standards.

UNIT I **9**

Consideration of the importance of testing-Identification of plastics-Determination ofnecessary manufacturing conditions-Assessment of properties of finished products inrelation to service requirements-Standard and specification-Application of national and international standards (BIS-

ASTM-ISO) for testing and their significance, Knowledge and exposure on Sectorial Testing Standards.

National and International standards-Test specimen preparation-Preconditioning and test atmosphere.

UNIT II **9**

Mechanical Properties: Density and dimensions-Hardness-tensile strength-compressive strength-shear strength-flexural strength-heat strength-impact strength-dynamic stress-strain Properties- creep-relaxation and set tests-friction and wear-abrasion test-fatigue-burst strength-and folding endurance

UNIT III **9**

Thermal Properties: Specific heat and thermal conductivity thermal dependant properties thermal Endurance-glass transition temperature-thermal yield tests-Heat deflection temperature-Vicat softening temperature-Marten's heat resistance test-low temperature brittle point and flexibility test-coefficient of thermal expansion-shrinkage-Thermal stability- Thermal ageing and flammability. Permeance Properties: Water absorption-soluble and insoluble matter-chemical resistance environmental stress cracking resistance-ageing-gas permeability-water vapour permeability and weathering.

UNIT IV **9**

Optical Properties -Refractive index-light transmission-haze-clarity-gloss-colour guard and microscope.Electrical Properties Insulation resistance-power factor-permittivity – dielectric strength- tracking resistance-arc resistance and antistatic test.

UNIT V **9**

Product testing-Pipe and fittings-film and sheets-container testing and FRP based products. Factors for designing tests for newer products Factors affecting the quality of materials and products Analysis of failure and its measurements Techniques of characterisation-Principles and application of DSC- TGA and FTIR Concepts of non-destructive testing

TOTAL : 45 PERIODS

OUTCOME

Upon completion of this course

- Ability to test the plastics materials for its chemical, mechanical, electrical, optical, thermal, and permanence properties as per the standard.
- Ability to identify the plastic materials by reverse engineering for some specified applications with the knowledge of testing.
- Ability to control the quality of plastics products by testing.

REFERENCES

1. Allen; W.S and Baker; P.N, Hand Book of Plastics Technology, Volume 2,Identification Testing & Recycling of Plastics, CBS Publishers and distributors, New Delhi 2004).
2. Brown; Paul F (Ed), Hand Book of Plastics Test Methods, Longman Scientific and Technical, Harlow (1988).
3. Brown; Roger P (Ed.), Hand Book of Polymer Testing, Marcel Dekker, Inc, New York (1999).
4. Plastic Engineering Hand Book & D-5 By Society of Plastics Industry Inc Identification & Analysis of PlasticsBy Haslam& Others..
5. Simple Methods for Identification of Plastics By Brawn, R.B.Analysis of Plastics By Crompton, J.

PA5202 POLYMER COMPOSITES ENGINEERING L T P C
3 0 0 3

OBJECTIVES:

- To impart knowledge of various types of composites and its advantages and needs.
- To make the student understand the various types of fiber materials and its applications for making Composites.
- To understand the knowledge of various resins materials used in processing of composites and the basic destructive and non-destructive testing of composites

UNIT I **9**

Introduction to composite material – classification - advantages - polymer composites Thermosetting and thermoplastic matrix materials – Reinforcements-Types and Forms-particulate, flake, fibrous etc.,- coupling agents-Principles of composite reinforcement. Effect of reinforcement on composite properties.

UNIT II **9**

Theory of composite materials - calculation of composite properties- mechanism of load transfer, minimum and critical fibre content, critical fibre length- Rule of mixtures – Halpin -Tsai - equation.

UNIT III **9**

Compounding of Thermoplastics- Twin screw extrusion, compression moulding- compounding of polyolefins, polystyrene and styrene copolymers, engineering polymers, wood floor and natural fiber filled plastics, compounding lines, post compounding operations.

UNIT IV **9**

FRP processing - important methods - hand layup, spray up, filament winding, compression moulding, injection moulding, resin, transfer moulding, reaction injection moulding, pultrusion, miscellaneous methods - machinery, operation, advantages and disadvantages.

UNIT V **9**

Characterization of Composites: Control of particle/fibre and porosity content, particle/fibre distribution, Interfacial Reaction of matrix-reinforcing component, Coating of reinforcing component, Strength analysis

Testing Quality control & end use of plastics – Testing for mechanical, electrical, thermal, optical and chemical properties, Determination of shelf life and gel time – Non-destructive testing methods. Application of composite- marine, chemical, railways, electrical and electronic industry, space structures, Robotics.

TOTAL: 45 PERIODS

OUTCOME

- Will be conversant with knowledge of various types of composites and its advantages and needs.
- Will be able to know various types of fibers and matrix materials and their applicationsin making composite products.
- Will understand the knowledge of various processing operations for composites and the basic destructive and non-destructive testing of composites

REFERENCES

1. Astrom; B.T, Manufacture of Polymer Composites, Chapman and Hall, London(1997).

2. Bunsell; A. R. and J. Renard, Fundamentals of Fibre Reinforced CompositeMaterials, Institute of Physics Publishing Ltd.,
3. Bristol (2005).Hollaway; Leonard (Ed.), Handbook of Polymer Composites for Engineers, Woodhead Publishing Ltd., Cambridge (1994), Reprint (2007).
4. Macosko; Christopher W., RIM: Fundamentals of Reaction Injection Moulding,Society of Plastics Engineer, Hanser Publisher, Munich (1989).Miller; Edward
5. Introduction to Plastics and Composites, Marcel Dekker, Inc., NewYork (1996).Technology I,II & III, Technomic 1989

PA5203 MOULD MANUFACTURING TECHNOLOGY LT P C
3 0 0 3

OBJECTIVES

- To impart knowledge on metal cutting and machine Tools
- To develop the knowledge on advanced mould manufacturing processes
- To learn the basics of measuring instruments for inspection and quality control

UNIT I MATERIAL AND HEAT TREATMENT 9

Materials: Introduction to Material- Types- Ferrous - Mould Steel – alloying elements - Non ferrous materials - Copper - Bronze - Beryllium Copper, Aluminium - Magnesium alloys and its significance as a material for mould making - Miscellaneous materials - factors considered for selection of materials- material for various mould elements - IS standards -British standards for mould materials.

Heat Treatment: Introduction to Heat treatment – Purpose –Heat Treatment Process and types - Annealing, Normalising, Hardening - Tempering – Quenching medium – Types and application. - Case Hardening process- Types & applications - Carburising, Nitriding, Cyaniding, Carbonitriding, Flame and Induction hardening- Advanced Heat treatment techniques - Vacuum hardening, Plasma Nitriding - Heat treatment for mould elements.

UNIT II METAL CUTTING AND MACHINE TOOLS 9

Mechanism of metal cutting - Orthogonal & oblique cutting - Types of chips - Types of tool - Single point and multi point cutting tool -Nomenclature - Tool signature, Cutting tool materials, Tool life, Influencing factor of Tool, Cutting fluid.

Introduction to Machine tools – Working principle, construction, operation and applications of Lathe, Shaper, Planner, Drilling, Grinding (Surface, Cylindrical, Tool & Cutter), Milling (Horizontal/Vertical/ Universal), Pantograph, Jig boring- Process Planning and procedure for manufacturing of various mould elements.

UNIT III CNC MACHINE TOOLS 9

Introduction to CNC Machines and classification -Lathe, Milling, Electric Discharge machining (EDM) and Wire-Cut EDM - Working principle, operation and application; Manual Part programming, Dimensioning method and coordinate system, G-code, M- code, Cutter radius and length compensation, Types of cutting tools, Tool holding devices, work holding devices, speed, feed and Cycles; Computer Aided Part program – CAM packages; Advantages, disadvantages of CNC machine tools.

UNIT IV MOULD FINISHINGAND ASSEMBLY 9

Mould finishing: Various techniques – Polishing-types, procedure and polishing tools, - Chromium Plating - Nickel plating -Photo chemical etching - EDM Finishing and Electroforming.

Mould Assembly: Check list for mould assembly- Fitting and assembly of various mould elements- Core insert, Cavity insert, Sprue bush, Ejection system assembly- Blue matching and Die Spotting- Venting - Final inspection- Fitting of locating ring and carrier bar- Mould trial. Introduction Mould Maintenance

UNITV METROLOGY 9

Need for measurement – Dimensional and Form tolerances- Precision and accuracy - Errors in measurement, Working principle and applications of Measuring instruments – Steel rule and divider, Vernier caliper, micrometer, vernier height gauge, vernier depth gauge, Dial indicator, Slip / Pin gauges, Bevel protector, Sine bar, Squares, Optical profile protector, Tool maker microscope, Optical flat and CMM.

Application of Surface plate – V block - Angle plate - Straight edge - feeler gauge - radius gauge - pitch gauge.

TOTAL: 45 PERIODS

OUTCOMES

Upon completing this course, the students will have

- Ability to select the machining process to manufacture the mould.
- Ability to use suitable measuring instruments for inspection of mold
- Ability to apply knowledge of finishing process to have the required mould surface.

REFERENCES

1. Douglas M. Bryce, Plastic Injection Molding manufacturing process fundamentals, Society of Manufacturing Engineers, Dearborn, Michigan.
2. HajraChouldhary S.K and Hajra Choudhury. AK., "Elements of workshop Technology", volume II, Media promoters and Publishers Private Limited, Mumbai.
3. Herbert Rees, Mold Engineering, Hanser Publishers, NY.
4. HMT Production Technology, TMH (India), 1992
5. Jain R K ," Engineering Metrology" , 19th Edition , Khanna Publishers , 2005
6. KlusStokhert (Edt.), Mold making handbook for Plastic Engineers, Hanser Publishers, NY, 1983
7. O.P. Khanna, "A text book of Materials Science and Metallurgy", Khanna Publishers.
8. Peter Jones, "The Mould Design Guide", SmithersRapra Technology Ltd., 2008
9. R.G.W.Pye, "Injection Mold Design", East West Press Pvt. Ltd., New Delhi.
10. W.A.J Chapman, Workshop Technology, Vol I & II, ELBS.

PA5204 BLENDING OF POLYMERS L T P C

3 0 0 3

OBJECTIVE

- To impart knowledge on selection, characterization& testing of blends and alloys
- To develop knowledge on properties & applications of polymer blends and alloys based on commodity plastics, engineering and speciality plastics

UNIT I 9

Introduction to polymer blends & alloys – Definitions and nomenclature – Criteria for making polymer blend –Selection of polymer for blend components –mechanism of mixing and dispersion,

mixing of solid-solid, liquid-liquid and liquids-solids, dispersive mixing, distributive mixing and laminar mixing, mixing entropic measures and its applications- mixing indices preparation of alloys & blends – economy of blending.

UNIT II **9**

Introduction–compatibilization mechanisms–Compatibilization methods–compatibilization by addition of copolymer reactive blending –General principles of phase equilibria calculation-theories of liquid mixtures containing polymer: Huggins-Flory theory, Gaslattice model, etc; Mechanisms of phase separation-general types of Polymer blends polymer crystallization-measurement of polymer/polymer interaction.

UNIT III **9**

Introduction – Principles of polymers miscibility and compatibility, inter-chain forces, interpenetrating network- Thermodynamics of polymer miscibility- Miscibility and flow behaviour of polymer blends – Immiscible blends – Flow behaviour of immiscible and miscible polymer blends. Complex flow – processing of polymer blends - Blend Preparation techniques - Melt blending - Solution blending - Latex or dispersion mixing

UNIT IV **9**

High performance polymer blends- Blends of PBI with polyimides- Polybenzimidazoles/polyarylate (PBI/PAr) Blends- Polybenzimidazoles/ Fluro containing polyamide-imide Blends- Fluro containing polyimide Blends- LCP/ Conventional Polymer Blend- LCP/LCP Blend.

UNIT V **9**

Morphology and phase separation in polymer blends - properties- Fourier transformed Infrared Spectroscopy (FTIR) – X-Ray Diffraction (XRD), Microscopic Techniques – Optical microscopy – Electron Microscopy: scanning electron microscopy –Transmission electron microscopy, Thermal analysis – Differential scanning calorimeter, Glass transition temperature, Light scattering – X-Ray Scattering Technique.

TOTAL: 45 PERIODS

OUTCOME

The students will have an

- Ability to demonstrate knowledge and understanding in the blends of various polymers, its solubility parameter, compatibility and phase separation and rheology of polymer blends and alloys.
- Ability to prepare a new blend to meet the requirement economically and environmental friendly.

REFERENCES

1. L.A.Utracki, Commercial Polymer Blends, Chapman & Hall, London, 1998.
2. R.P. Singh, C.K. Das, S.K. Mustafi, Polymer Blends and Alloys an Overview, Asian Books Pvt. Ltd., New Delhi, 2002.
3. R. Paul & Seymour Newman, Polymer Blends, Vol. 1& 2, Academic Press, New York, 1978

PA5211 PLASTICS PROCESSING LABORATORY II **L T P C**
0 0 4 2

OBJECTIVE

- To learn about microprocessor controlled injection moulding machine, Blow moulding process, rotational moulding , thermoforming with different moulds and material.

- To understand the possible defects, its causes and setting of process parameter.

EXPERIMENTS

1. Microprocessor controlled Injection moulding operation
2. Blow Moulding Automatic
3. Vacuum Forming
4. Rotational Moulding
5. Coating of Plastics
6. Welding & Sealing of Plastics
7. Screen Printing
8. Machine Maintenance
9. Mould Study
10. FRP – Hand layup process
11. Co-extrusion

TOTAL : 60 PERIODS

OUTCOME

- Ability to select the suitable process parameter.
- Ability to analyse cause for defects and trouble shoot it.

REFERENCES

1. A.S. Athaly, Injection Moulding Practice, Multi-Tech. Publishing Co., New Delhi, 1997.
2. Irvin Rubin, Injection Moulding Theory and Practice, A. Wiley interscience Publication.1972.
3. Lee, Blow Moulding Design Guide, Hausar Publishers, Munich, 1998.
4. Friedhelm Hensen, Plastics Extrusion Technology, Hansar Publishers, Vienna, 1988

LABORATORY REQUIREMENTS

1.	Microprocessor controlled inj. moulding machine	-	1 No.
2.	Blow moulding machine (Automatic)	-	1 No.
3.	Vacuum forming machine	-	1 No.
4.	Rotational moulding machine	-	1 No.
5.	Plastics coating machine	-	1 No.
6.	Ultrasonic welding machine	-	1 No.
7.	Plastic sealing machine	-	1 No.
8.	Printing machine (on plastics)	-	1 No.
9.	Machine maintenance kit	-	1 No.
10.	Moulds maintenance kit	-	2 Nos.
11.	Moulds for plastic products	-	1 No.
12.	FRP hand layup kit	-	1 No.
13.	Plastic co-extrusion film plant	-	1 No.

PA5212 PLASTICS PRODUCTS/TOOL DESIGN LABORATORY L T P C
0 0 4 2

OBJECTIVE

- To learn the use of Computer Aided Design in mould designing.
- To analyse the flow behaviour of plastics materials while processing using mold flow software.

LIST OF EXPERIMENTS

I. Plastics Product Design using CAD

2D and 3D modelling of plastic components

II. Mold Design using CAD

a) Injection Mould design

Design calculations for No. of cavities, Selection of injection moulding machine, shot capacity, plasticizing rate, Clamping force and 2 D / 3 D Modelling for Two plate, Three Plate and split Moulds

b) Compression Mould Design

Design calculations for No. of cavities, Flash thickness allowances, Design of loading chamber, Bulk factor, Pressure pad, Heaters and 2 D / 3 D Modelling for Compression Mould.

c) Transfer Mould Design

Design calculations for Pot, Bulk factor, Heaters and 2 D / 3 D Modelling 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 Modelling for Blow Mould.

e) Extrusion Die Design

Design calculations and 2 D / 3 D Modelling for Extrusion Die

III. Mouldflow Analysis

Design Optimization of Plastic Part, Mould and Process parameters optimization using Moldflow Software

- Modelling, Mesh Creation, Mesh Checking, Surface repair , Creating Feed system and cooling system.
- Analysis: Gate location, Molding window Fill, Flow, Cool, Pack, Warp, Shrinkage, Stress

TOTAL : 60 PERIODS

OUTCOMES

- Ability to design and develop the moulds using CAD/ CAM/CAE software.
- Ability to predict the flow behaviour of the materials in the designed mould.

LIST OF EQUIPMENT FOR BATCH OF 30 STUDENTS

Sl.No	Description	Qty.
1	Computer Systems	30 Nos.
2	2 D & 3D Modeling Software	30 Licenses
3	Flow Simulation software	30 Licenses
4	Printer	1 No.

.

REFERENCES

1. Design calculations for Compression moulds, Machinery publications, Yellow series, U.K.
2. Herbert Rees, Mould Engineering, Hanser publishers, Munich, Vienna N.Y. 1994.
3. Jay Shoemaker “Moldflow Design Guide: A Resource for Plastics Engineers”, Volume 10, Hanser, 2006
4. LaszcoSors and ImreBlazs, Design of Plastic Moulds and Dies, Elsevier, Amsterdam - Oxford - Tokyo - NY, 1989.
5. Mould Flow Manual & Part - Adviser Manual - MOULD FLOW.

6. P.S.Cracknell and R.W.Dyson, Hand Book of thermoplastics injection mould design, Chapman & Hall, 1993.
7. R.G.W.Pye, Injection Mould Design, SPE Publication.
8. Technical Directory on Design and Tooling for plastics, CIPET, Guindy, Chennai.

PA5213 PLASTICS TESTING LABORATORY II L T P C
0 0 4 2

OBJECTIVE

- To train the students in testing of plastics for properties.
- To understand the various testing done on different plastics products.

LIST OF EXPERIMENTS

1. Compounding, Blending using Two Roll Mill and Specimen
2. Determinations of Carbon Black Content and Dispersion
3. Determination of environmental stress cracking resistance For olefins
4. Testing of HDPE/RPVC Pipes
5. Testing of Water Storage Tanks/Containers
6. Testing of Films/Sheets
7. Testing of HDPE/PP Woven Sacks/Tapes
8. Testing of Bottles/Vanaspati, Ghee, Milk Packing
9. Testing of Plastics Products for Determination of Mechanical Properties

TOTAL:60 PERIODS

OUTCOMES

At the end of this course,

- Ability to prepare specimens through compounding, two roll mill for testing of various properties of plastics materials.
- Ability to test the give plastics product as per the standard and apply the result to take a decision.

REFERENCES

1. ASTM test standards for plastics Vol.8.01 to 8.04, 9.01 & 9.02, 2002.
2. ISO test standards, 1998.
3. J.S. Anand, K. Ramamurthy, K. Palanivelu& C. Brahatheeswaran, How to IdentifyPlastics by Simple Methods, 1997.
4. R.P. Brown, Hand Book of Plastics Test Methods, George Godwin Ltd., London,1981
5. Vishu Shah, Hand Book of Plastics Testing Technology, John Wiley & Sons. Inc.New York, 1998.

EQUIPMENT / DEVICES REQUIRED

S.No	**Name of the Equipment**	**Quantity Required**
1	Ribbon Blender	**1**
2	Compounding Extruder	**1**
3	Injection moulding machine	**1**
4	Compression moulding machine	**1**
5	Two roll mill	**1**

6	Contour cutter	**1**
7	Carbon black content tester	**1**
8	Environmental stress cracking resistance tester	**1**
Mechanical and Product Testing		
9	Ribbon Blender	**1**
10	Compounding Extruder	**1**
11	Universal testing machine	**1**
12	Tear strength tester	**1**
13	Impact strength tester	**1**
14	Abrasion resistance tester	**1**
15	Burst strength tester	**1**
16	Humidity chamber	**1**
17	Gas permeability tester	**1**
18	Hydrostatic bursting pressure tester	**1**
19	Reversion tester	**1**
20	Falling Dart Impact Tester for films andPipes	**1**
Electrical and Optical Properties		
21	Volume and Surface resistivity	**1**
22	Dielectric strength	**1**
23	Arc Resistance	**1**
24	Haze meter	**1**

PA5311 **SEMINAR** **L T P C**
0 0 2 1

The seminar power point presentation shall be fundamentals oriented and advanced topics in the appropriate branch of engineering 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 presentation of the seminar.

TOTAL:30 PERIODS

PA5312 **PROJECT WORK (PHASE I)** **L T P C**
0 0 12 6

Project report: To be prepared in proper format decided by the University. The report may include the aspects of the literature review. Members of a project group shall prepare and submit the report.

A comprehensive oral Viva-voce examination will be conducted to assess the student's, depth of understanding in the specified field of engineering and technology..etc.

An internal and external examiner is appointed by the University for the Conduct of viva voce University examination.

PA5411 **PROJECT WORK (PHASE II)** **L T P C**
0 0 24 12

Project report: To be prepared in proper format decided by the University. The report shall record all aspects of the work. Members of a project group shall prepare and submit the report.

A comprehensive oral Viva-voce examination will be conducted to assess the student's intellectual achievement, depth of understanding in the specified field of engineering and technology..etc.

An internal and external examiner is appointed by the University for the Conduct of viva voce University examination

PA5001 **ADVANCED PLASTICS PROCESSING TECHNOLOGY** **L T P C**
3 0 0 3

OBJECTIVES

- To understand the specialized injection moulding process viz., Co-injection moulding, Two-colour injection moulding process, Gas assisted Injection Moulding, Reaction Injection Moulding, Liquid injection moulding, structural foam moulding and to understand the effect of shrinkage, merit & demerits of the process
- To understand advanced blow moulding process & advanced Extrusion process.
- To expertise the student with sufficient background for selection of processing techniques.

UNIT I SPECIALIZED INJECTION MOULDING PROCESS - I 9

Introduction - Co-injection moulding, Two-colour injection moulding process - applications, Gas assisted Injection Moulding - Basic processes and procedures - Moulding aspects -shrinkage and summary. Reaction Injection Moulding (RIM) - Process - Mould – ProcessControls – Merits.

UNIT II SPECIALISED INJECTION MOULDING PROCESS – II 9

Multi-layer Moulding, Counter flow moulding, Liquid Injection Moulding processes. Structural foam moulding - Low pressure and high pressure processes - Merits &demerits.

UNIT III ADVANCED BLOW MOULDING - I 9

Introduction - Classification of advanced Blow moulding processes - Deep draw Double Wall Blow Moulding Technology - Split moulds- Versatility - Applications. Press Blow Moulding Technology Process - Applications, Three dimensional Blow Moulding Process -Applications.

UNIT IV ADVANCED BLOW MOULDING – II 9

Stretch blow moulding - Injection stretch blow moulding - Extrusion stretch blow moulding- Process - Merits & demerits - Applications. Multi-layer Blow Moulding - Process -Applications.

UNIT V ADVANCED EXTRUSION PROCESSES 9

Introduction - Profile Extrusion - Material - Process - Process optimisation - Cooling Profileapplications. Process, downstream equipment’s - dies and application.Multi-layer films, co-extruded sheets, Pipes, Corrugated pipes.

TOTAL : 45 PERIODS

OUTCOMES

- Ability to select the advance processing technique as per the requirement.

REFERENCES

1. Charles A Harper Handbook of plastics Processes.
2. Crawford, R.J. , Plastics Engineering, 3rd Ed., Elsevier India Pvt. Ltd., New Delhi 2006.
3. Engineered Materials Handbook, ASM International Handbook committee, USA
4. Fisher, E.G., Extrusion of Plastics, 2nd Ed., Little Books Pvt. Ltd., London, 1964.
5. Friedhelm Henson, Plastics Extrusion Technology, Hanser Publishers, New York,1988.
6. Hensen, Freidhelm, Plastics Extrusion Technology, 2nd Ed., Hansen Publishers, Munich 1997.
7. James F. Stenvension, Innovation in Polymer Processing Moulding, Hanser Publishers, New York, 1996.
8. Lee, N. C., Plastic blow Moulding Handbook, Van Nostrand Reinhold Rosato, Donald and Rosato, Dominick.V., Injection Moulding Handbook, 2nd Ed., International Thomson Publishing company, Newyork 1995.
9. Levy, Sydney and Carley, James F., Plastics Extrusion Technology Hand Book, 2nd Ed., Industrial Press Inc., Newyork 1989.
10. Onasch, J., Back or forward to Basics in B, P and R, May 1987
11. Osswald, Tim A, Lih-Sheng Turng and Gramann, Paul, Injection Molding Hand Book, 2nd Ed., Hanser Publisher, Munich 2008Rubin, Irvin I., Injection Molding Theory & Practice, Johnwiley& sons Inc.,US, 1972
12. Rubin, Irvin I., Injection Molding Theory & Practice, Johnwiley& sons Inc.,US, 1972.
13. Schar, J., Press blowing option for tough to blow parts, SPE ANTEC April'87.
14. Strong, Brent A., Plastics – Materials & Processing, 3rd Ed., Pearson Education Ltd., Newyork, 2006.

PA5002 PLASTICS PACKAGING TECHNOLOGY L T P C
3 0 0 3

OBJECTIVE

- To enable the students to understand the concepts of plastics materials used in packaging industries,
- To understand the machinery used in packaging field and testing equipments used for packaging product.

UNIT I 9

Introduction to Packaging – Functions of packaging – Major packaging materials viz. Polyolefins, Polystyrene, Polyvinylchloride, Polyesters, Polyamides (Nylons), Polycarbonate and Newer materials such as High Nitrile polymers, Polyethylene Naphthalate (PEN), Polyetherimide (PEI) and LCP – Properties and Applications in Packaging.

UNIT II 9

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.

UNIT III 9

Edible and bio-based food packaging materials, Edible film and coating, Polysaccharide based coatings, Lipid based coatings, Protein based coating, First, Second and Third bio-based packaging materials. Permeability of thermoplastic polymers, Multilayer films, Processing,

Deteriorative reaction in foods, Enzyme reactions, Chemical reactions, Physical change, Biological change, shelf life of foods, Factors controlling shelf life.

UNIT IV **9**

Asceptic packaging of foods, Sterilization of packaging materials, Packaging of microwavable foods, Active and intelligent packaging, Modifies atmospheric packaging, Packaging of fresh foods, Packaging of horticultural products.Packaging of dairy products, Packaging of cereal, snack foods and confectionary, Packaging of beverages, Comparison of polymer packaging with paper, metal and glass materials, printing processes, Safety and legislative aspect of packaging.

UNIT V **9**

Mechanical properties – Tensile properties, Impact properties, Tear strength, Burst strength, Stiffness, Crease or flex resistance, Co-efficient of friction, Blocking, Orientation and shrinkage. Optical Properties – Clarity, Haze and gloss Barrier Properties – Oxygen transmission, Water vapour transmission rate – Migration.

TOTAL: 45 PERIODS

OUTCOMES

Upon completing this course, the students

- Will gain the knowledge on the plastic packaging process and materials.
- Will familiarize in testing of plastic packaging
- Will attain the knowledge of thermoforming packaging

REFERENCES

1. Gordon L. Robertson, Food Packaging Principles and Practice, Marcel Dekker, Inc., New York 1993.
2. Louis T. Manzione, Plastic Packaging of Microelectronic Devices, Van Nostrand Reinhold, New York, 1990.16

PA5003 COATING SCIENCE AND TECHNOLOGY **L T P C**
3 0 0 3

OBJECTIVES

- To know about the various components in a paint and functions of each component and their advantages.
- To learn the synthesis and mechanism of film formation of binders in surface coating,
- To understand the formulations of different types of paints.
- To know the methods of application of surface coatings and paints, evaluation of paints and their applications.

UNIT I INTRODUCTION TO PAINTS **9**

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

UNIT II FORMULATION AND PROPERTIES OF PAINTS **9**

Essential concepts of paint formulation and paint properties : paint preparation (pigmentdispersion), surface preparation and paint application, paint properties and their evaluationmechanism 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.

UNIT III COATING SURFACES 9

Mathematics of paint formulation, formulations of coatings as finishes (automotiveappliances, coil, can, marine, aircraft etc) and for various substrates (Steel, timber,masonry, plastics etc.)

UNIT IV SPECIALTY COATINGS 9

State of the art technologiesforradiation durable, nonpolluting, powder, high solids.

UNIT V WATER BORNE COATINGS 9

A Fundamental Constituent of water-borne coatings, types of aqueous coatings systems, binders in water-borne coatings, additives in water-borne coatings, pigments and fillers, action of amines and auxiliary solvents in aqueous, manufacture of water-bornecoatings

TOTAL: 45 PERIODS

OUTCOME

- Students learn about various components in paint formulations and different typesof paints and surface coatings. They understand the mechanism of film formationand advantages and disadvantages of various binders in paint/surface coating.They also learn about various techniques for application of coatings and theirevaluation.

REFERENCES

1. Doren“ Water-borne” Hanser 1994.
2. Outline of Paint Technology, W.M. Morgans (3rd Edition – Recently CBS Publishers.
3. Paints, Coatings and Solvents, Dieter Stage (Ed.) – 2nd Edition – WernorFreitag Ltd(Eds)
4. Principle & Paint Formulation, R. Woodbroidge (Ed) – 1991

PA5004 PLASTICS MOULD AND PRODUCT DESIGN LT P C
3 0 0 3

OBJECTIVE

- To learn the design concepts for various mould elements.
- To learn the basic design aspects related to Injection Mould , Compression Mould, Transfer Mould, Blow Mould and Extrusion Dies.

UNIT I PRODUCT DESIGN 9

Principles & Methodical approach for Product Design – Product Design Appraisal- Tooling Aspects on Product Design – Cost Analysis for Product Design.

Features: Geometry Features- Wall thickness, Taper & Draft, Radii, Fillets, Ribs, Bosses Holes, Undercuts –External & Internal- Moulded threads- Inserts - Shrinkage- Assembly Features - Fits & Tolerances - Snap Fits - Hinges – Types -Design of Integral hinges - Welding - Bonding.

Structural Elements: Design of Tension bars, Columns, Beams, Pipes, Plates and Shells- Design of Joints – Bolted joints and Bonded joints- Design of plastics under Static load & dynamic load- Design of plastic Gears, Bearings, Springs.

UNIT II Injection Mould Design 9

Introduction – Elements of Injection Mould - Factors considered for Mould Design- -Shot Capacity- Plasticising Rate -Clamping Force- Injection Time – Cooling Time - Number of Cavities –Layout of Cavities.

Design of Injection mould systems – Parting surface and its types - Core – Cavity – Bolster- construction methods for core & cavity - Guide pillar- Guide bush - Sprue bush - Locating Ring- Standard Mould System – Mould alignment – Mould Assembly – Mould Clamping.

Feed System: Sprue – types of sprue – Runner – types of runner - cross section and size of runner –runner layout – balancing of runners – Gates - Gate location and balancing - types of gates – Mould Venting.

UNIT III **9**

Ejection System: Requirements – Elements of Ejection system - Ejector grid, Ejector plate assembly, Ejection techniques – Ejection from fixed half - Sprue Pullers- Ejection Force Calculation - Ejection Assembly Actuation.

Mould Temperature Control System: Introduction -Heat Transfer Fluids- Chillers- Temperature Controllers - Factors Affecting the Cooling Cycle -Cooling Efficiency - Mould Cooling Variables - Cooling Calculations -Cooling of Integer type mould plates - Cooling of Insert Bolster assembly - cooling of other mould parts- connections of cooling channels and seals.

Types of Injection Moulds: Cold Runner – Hot Runner – Hand – Semi Automatic – Automatic Two plate - Three Plate – Moulds for Internal & External Undercuts.

UNIT IV DESIGN OF COMPRESSION & TRANSFER MOULD **9**

Compression Mould Design: Introduction -Types - Open flash, Semi-positive, Positive moulds- Bulk factor - Design of loading chambers and Pressure pad - Calculations of Flash thickness, Projected area, Compression Pressure, Clamping Force, No. of impressions- Design of heating system - Advantages , Disadvantages and Applications Compression Mould.

Transfer Mould Design: Introduction -Types – Design of Pot and Plunger - Calculations of Projected area, Transfer Pressure, clamping force - Design of Pressure pad and Feed system - Advantages, Disadvantages and Applications of Transfer Mould

UNIT V DESIGN OF OTHER MOULDS & DIES **9**

Blow Mould Design: Introduction - Types of blow moulds - Blow ratio - Parison design – Pinch off design - parting line - mould cooling - mould alignment.

Rotational Mould Design: Introduction – Construction- Advantages, Disadvantages and Applications.

Extrusion Die Design: Principles of extrusion - construction of die - die geometry - die swell - die land design - sizing die -Advantages, Disadvantages and Applications.

TOTAL: 45 PERIODS

OUTCOMES

Upon completion of this course,

- The students will understand the basics of plastics mould design and also product design.
- They also acquire knowledge about various moulds for different processing techniques.

TEXTBOOKS

1. Robert A. Malloy, “Plastic Part Design for Injection Moulding”, Hanser Publishers, Munich Vienna, New York, 1994.
2. Peter Jones, The Mould Design Guide, SmithersRapra Technology Limited, Shawbury, Shrewsbury, Shropshire, SY4 4NR, UK, 2008,
3. Injection Mould Design for Thermoplastic - By Pye, R.G.W.

REFERENCES

1. Belofsky, H, “Plastics Product Design and Processing Engineering, Hanser Publishers, Munich Vienna New York, 1994.
2. Dym J.B Injection Mould & Moulding A practical manual, Springer, 2nd ed. XVIII, 396P, 1987,
3. Fundamentals of plastics mould design – By Sanjay K Nayak, Pratap Chandra Padhi and Y. Hidayathullah

4. Injection Mould Design Fundamentals (Vol. I& II) - By Glanvill& Denton
5. Injection Moulds 130 Proven Design Gastrow
6. Plastics Moulds & Dies - By Sors, & Others.
7. R.D. Beck “Plastics Product Design”, Van Nostrand Reinhold, New York,1980

PA5005 CAD/CAM/CAE APPLICATIONS IN MOULD / TOOL DESIGN LT P C
3 0 0 3

OBJECTIVES

To enable the students

- To provide an overview of how computers are being used in Design of Plastic Component, Manufacturing of Tool and Analysis of mould flow.
- To develop the knowledge of computer aided manufacturing.

UNIT I COMPUTER GRAPHICS 9

Fundamentals: Output primitives (Points, lines, curves, etc.,) - 2-D and 3D Transformations- Homogeneous Coordinates- Windowing, Viewing and clipping transformation- Introduction to curves- Analytical Curves- circle and conics- Synthetic Curves Bezier and B-spline curve.

Graphics Standards: Standards for computer graphics- Graphical Kernel System (GKS) - standards for exchange images- Open Graphics Library (OpenGL) - Data exchange standards - IGES, STEP, CALS etc. - Communication standards

UNIT II COMPUTER AIDED DESIGN (CAD) 9

Surface modelling: Bezier and B-Spline surface- Bi- linear surface- Boundary Representation- Sweep representation.

Solid modelling: Primitives- Boolean set operations- Boundary Representation - Constructive Solid Geometry, User interface for solid modelling, Introduction to Parametric and Variation modelling, Creation of prismatic and lofted parts based on software packages.

Assembly Modelling: Assembly of parts, Tolerance analysis, Mass property calculations, and Interference Checking

UNIT III COMPUTER AIDED MANUFACTURING (CAM) 9

Introduction to NC machines, CNC machines, Direct Numerical Control (DNC), Advantages & Disadvantages, Working principle of CNC machines - Introduction to CAM software packages -G Codes & M Codes – Part programming for CNC Turning Center and CNC Machining Center.

UNIT IV FINITE ELEMENT ANALYSIS (FEA) 9

Introduction to Finite Element Analysis (FEA), Types of analysis - Procedure for finite element analysis -Finite Element Analysis packages, and its application; Analysis of One Dimensional Bar elements- Derivation of Shape function and Stiffness matrix and force vector – Assembly of matrix – Field problems.

UNIT V MOLD FLOW ANALYSIS 9

Introduction to Moldflow analysis- Design principles- Product design and Moldflow - Sequence of analysis- Moldflow concepts- Meshes used in Moldflow analysis- Types, Requirement- Geometry Creation- Importing Geometry; Shirkages and Warpage- injection molding and shrinkage, basic cause of warpage and shrinkages ; Moldflow design procedure- Analysis steps framework, Evaluate an Initial design, optimized the design; Part defects.

.**TOTAL : 45 PERIODS**

OUTCOME

- Upon completion of this course, the students will acquire the knowledge of computer aided design and manufacturing for moulds for plastics processing.
- Knowledge on various CNC machining processes used in Mould manufacturing.
- They also learn about various types of analysis involved in Mouldflow.

REFERENCES

1. Chris McMahon and Jimmie Browne “CAD/CAM Principles", "Practice and Manufacturing management “ Second Edition, Pearson Education, 1999.
2. Donald Hearn and M. Pauline Baker “Computer Graphics”'. Prentice Hall, Inc, 1992.
3. Ibrahim Zeid “Mastering CAD CAM” Tata McGraw-Hill Publishing Co.2007
4. Jay Shoemaker “Moldflow Design Guide: A Resource for Plastics Engineers”, Volume 10, Hanser, 2006
5. Radhakrishnan, P. &Subramanyan. S “CAD/CAM/CIM” , (Wiley Eastern Ltd., 1994).
6. Rao P N, Tiwari N K, Kundra T, “Computer Aided Manufacturing” Tata McGraw Hill 2014.
7. Seshu.P, “Text book of Finite Element Analysis” PHI learning Private limited, 2008.

PO5091 RESEARCH METHODOLOGY L T P C
3 0 0 3

OBJECTIVES

- To gain insights into how scientific research is conducted.
- To help in critical review of literature and assessing the research trends, quality and extension potential of research and equip students to undertake research.
- To learn and understand the basic statistics involved in data presentation.
- To identify the influencing factor or determinants of research parameters.
- To test the significance, validity and reliability of the research results.
- To help in documentation of research results.

UNIT I INTRODUCTION TO RESEARCH METHODS 9

Philosophy of Science, Evolutionary Epistemology, Scientific Methods, Hypotheses Generation and Evaluation, Code of Research Ethics, Definition and Objectives of Research, Various Steps in Scientific Research, Types of Research; Research Purposes - Research Design - Survey Research - Case Study Research.

UNIT II DATA COLLECTION AND SAMPLING DESIGN 9

Sources of Data: Primary Data, Secondary Data; Procedure Questionnaire- Survey and Experiments – Design of Survey and Experiments - Sampling Merits and Demerits - Control Observations - Procedures – Sampling Errors.

UNIT III STATISTICAL MODELING AND ANALYSIS, TIME SERIES ANALYSIS 9

Probability Distributions, Fundamentals of Statistical Analysis and Inference, Multivariate methods, Concepts of Correlation and Regression, Fundamentals of Time Series Analysis and Spectral Analysis, Error Analysis, Applications of Spectral Analysis.

UNIT IV POLYMER RESEARCH 9

Polymer synthesis–structure property relation- characterization- testing- principles and

methodology.

UNIT V RESEARCH REPORTS 9

Structure and Components of Research Report, Types of Report, Layout of Research Report, Mechanism of writing a research report

TOTAL : 45 PERIODS

OUTCOMES

- Ability to critically evaluate current research and propose possible alternate directions for further work
- Ability to develop hypothesis and methodology for research
- Ability to comprehend and deal with complex research issues in order to communicate their scientific results clearly for peer review.

REFERENCES

1. Bendat and Piersol, Random data: Analysis and Measurement Procedures, Wiley Interscience, 2001.
2. C.R. Kothari, Research Methodology Methods and Techniques, 2/e, VishwaPrakashan, 2006.
3. Donald R. Cooper, Pamela S. Schindler, Business Research Methods, 8/e, Tata McGraw-Hill Co. Ltd., 2006.
4. Fuzzy Logic with Engg Applications, Timothy J.Ross, Wiley Publications, 2nd Ed[d]
5. Genetic Algorithms in Search, Optimization, and Machine Learning by David E. Goldberg.
6. Jenkins, G.M., and Watts, D.G., Spectral Analysis and its Applications, Holden Day, 1986.
7. Richard I Levin amp; David S.Rubin, Statistics for Management, 7/e. Pearson Education, 2005.
8. Shumway and Stoffer, Time Series Analysis and its Applications, Springer, 2000.
9. Simulated Annealing: Theory and Applications (Mathematics and Its Applications, by P.J. van Laarhoven& E.H. Aarts[e]

PA5006 PLASTICS CHARACTERIZATION TECHNIQUES L T P C

3 0 0 3

OBJECTIVES

- To familiarise the student with the common methods used in the analytical characterization of polymers
- To provide the student with an understanding of the fundamental physics and chemistry used by these techniques
- To expertise the student with a sufficient background to select the appropriate method of characterization and solve a given problem

UNIT I MOLECULAR WEIGHT DETERMINATION 9

Importance of molecular weight-Molecular weight averages – calculation of different molecular weight averages- Molecular weight determination techniques-Absolute andrelative method- End group analysis, Colligative Properties - Ebulliometry, Membrane osmometry and Vapour phase osmometry, Light scattering techniques, Dilute Solution viscometry and Gel Permeation Chromatography.

UNIT II SPECTROSCOPIC CHARACTERIZATION 9

Introduction to Spectroscopic techniques –properties of electromagnetic radiation-UVVisible Spectroscopy – fundamentals, instrumentation and application to polymers. Infrared and Raman Spectroscopy – fundamentals, instrumentation and application to polymers. Nuclear Magnetic Resonance (NMR) Spectroscopy – principles of magnetic resonance, instrumentation and application to polymers. Electron Spin Resonance Spectroscopy- theory, experimental considerations, polymerization studies, degradation and relaxation.X -Ray Diffraction-generation and properties of X-rays, diffraction theory, wide- and small-angle scattering, applications to polymers.

UNIT III MICROSCOPIC AND CHROMATOGRAPHIC CHARACTERIZATION 9

Light Microscopy - Scanning electron microscopy – introduction, design and operation of SEM, primary, secondary, back scattered electrons and X- rays, application to polymers.Transmission electron Microscopy- layout of the TEM, diffraction, resolution, contrast, application to polymers and scanning transmission electron microscopy. Gas chromatography and GC-MS- theory and instrumentation, analysis of residual monomer like VCM, Acetaldehyde, Acrylonitrile and Styrene content, additive analysis in Polymers by Gas Chromatography and GC-MS.

UNIT IV THERMAL CHARACTERIZATION 9

The basis of Thermal Analysis – First and second order transitions in polymers- melt and cold crystallisation- Differential Thermal Analysis (DTA) and Differential Scanning Calorimetry (DSC) – principle, instrumentation and application to polymers-crystallisation kinetics Thermo-mechanical Analysis (TMA) – Dynamic Mechanical Thermal Analysis(DMA) and Dielectrical Thermal Analysis-Theory and principle, instrumentation, application to polymers. Thermo gravimetric Analysis (TGA)- principle, instrumentation and application to polymers, degradation kinetics.

UNIT V RHEOLOGICAL CHARACTERIZATION 9

Introduction and definitions related to fluid flow - Newtonian and non-Newtonian and viscoelastic fluids. Rheological properties - viscosity, melt-flow, relationships describing temperature and shear rate dependence on the rheological behaviour of amorphous and crystalline plastics materials, Simple shear flow and its application for measurement of viscosity as well as normal stresses. Simple elongation flow and its significance. Dynamic flow behavior-steady shear and oscillatory shear responses- time dependent fluid responses. Viscosity measurements - capillary rheometer, viscometer, torque rheometers, cup flow and spiral flow tests for determination of flow behaviour.

TOTAL : 45 PERIODS

OUTCOME

After completion of the course, the student able to

- Predict both qualitative and quantitative basis on the structure, properties andcomposition of a polymer
- Analyze and interpret the data taken by physical characterization methods(thermal analysis, microscopy, scattering, spectroscopy and mechanical methods)

REFERENCES

1. Campbell and J. R. White, Polymer Characterization Physical Techniques, Chapmanand Hall, London, 1989.
2. Charles L. Rohn, Analytical Polymer Rheology, Hanser Publishers, Munich, 1995.
3. Edith A. Turi, Thermal Characterization of Polymeric Materials, Academic Press, New York,1991.

4. Fred W. Billmeyer, J. R. Text book of Polymer Science, John Wiley & Sons,Singapore, 1994.
5. J. Spells, Characterization of Solid Polymers, Chapman and Hall, London, 1994.
6. Seymour/Carraher's Polymer Chemistry An Introduction, Marcel Dekker, Inc., NewYork, 1996.
7. T.R. Crompton, Characterization of Polymers, volume 1 and 2, SmithersRapra technology limited, 2008

PA5007 PHYSICS AND RHEOLOGY OF POLYMERS L T P C
3 0 0 3

OBJECTIVE

- To understand the conformational property of polymer chain using different models
- To study the chain conformation in polymer solution and melt based on thermodynamics
- To introduce fundamental flow properties and methods used to investigate the flow behaviour under stress
- To understand the flow behaviour in different processing methods

UNIT I MOLECULAR CONFORMATION AND CONFIGURATION 9

Potential and conformational energy of molecules-polymer conformation and configuration–isomerism in polymers- stereo isomerism, geometrical isomerism, sequential isomerism Conformation of an ideal chain-mean square end to end distance-freely jointed and freely rotating chain model, worm like chain model, hindered rotation model. Radius of gyration of an ideal chain. Real chain- excluded volume, Flory theory of polymer in a solvent,deforming real and ideal chains.

UNIT II ELASTICITY 9

Thermoelasticity -Thermodynamics of rubbers –Flory construction- entropic and energetic contributions to the elastic force in rubbers –unentangled rubber elasticity- Affine network model-Phantom network model-entangled rubber elasticity-Edwards tube model-Mooney-Rivlin model

UNIT III SOLUTION PROPERTIES 9

Polymer solutions-theta condition-Thermodynamic view of miscibility-upper critical solution temperature (UCST)- lower critical solution temperature (LCST)-Concentration regimes inpolymer solutions Viscoelasticity- elastic deformation-irrecoverable deformation - models of viscoelastcity-Voigt-kelvin-Maxwell-Burger models- WLF equation-TTS curve- Boltzman super position principle-stress relaxation-creep and creep recovery-

UNIT IV FLOW BEHAVIOUR 9

Basics of rheology- shear stress-shear strain-strain rate-different types of fluids-Newtonian and Non-Newtonian fluids- flow behaviour of different Non- Newtonian fluids-zero shear viscosity-steady shear and oscillatory shear experiments. Methods to measure flow properties-capillary rheometer-parallel plate rheometer-cone and plate rheometer-Cup and cone viscometer-Measurement of normal stresses. Theories of viscosities of dilute and concentrated Solutions.

UNIT V MELT RHEOLOGY AND RHEOMETRY 9

Rheology of dilute and concentrated suspensions, Flow behaviour of polymer melts duringInjection moulding-Extrusion: Film extrusion, Sheet extrusion and Blow mouldings. Bubble inflation rheometer, compression rheometer, stress relaxation instruments. Torque rheometers, rotational & sliding surface rheometers and their use in determining processability.

TOTAL : 45 PERIODS

OUTCOMES

At the end of the course student able to

- Know the conformational change of polymer chains in solution and melt
- Understand and measure the basic flow properties of polymers
- Relate the polymer rheology to properties of polymeric materials and processing

REFERENCES

1. Elements of Physical Chemistry: S. Glasstone and D. Lewis, Macmillan India Press, Madras, 1995.
2. Introduction to Polymer Viscoelasticity: J.J. Alkonis and W.J.Macknight–Willey Inter Science, New York ,1982.
3. Polymer Melt Rheology: F.N.Cogswell, George Goodwin Ltd. and P. R. Londo, John Wiley and Sons, 1981.
4. Polymer physics: Michael Rubinstein and R.H. Colby, Oxford University press ,2003
5. Polymer Physics: Ulf W. Gedde, Chapman & Hall, 1995
6. Rheology of Polymers: G.V.Vinogradov and A.YaMalkin, Mir Pub, Moscow, 1980.
7. Viscoelasticity of Polymers: D.D.Ferry III Edn. John Willey and Sons, New York, 1981

PA5008 POLYMER FOR ADVANCED APPLICATIONS L T P C

3 0 0 3

OBJECTIVE

- To familiarize the students with a specific class of advanced polymers defined on the basis of their specific properties.
- To emphasize on the study of property correlation with various aspects and processing requirements for specialty polymers, engineering and specialty applications like high performance applications, biomedical, aerospace engineering, electronics and other areas.

UNIT I LIQUID CRYSTALLINE POLYMERS (LCPS) 9

Introduction, history, structural requirements, types of liquid crystalline (LC) phases, types of liquid crystalline polymers, anisotropic properties, characterization of LC phases (DSC, POM, XRD, NMR, FTIR, Dielectric etc.), LC blends and composites, LC elastomers, rheology of liquid crystalline polymers, applications of LC polymers- optical, high strength fibers, MEMS etc.

UNIT II CONDUCTING POLYMERS 9

Theory of conduction, semi-conductors and conducting polymers, band theory, requirements for polymer to work as conductor, types of conducting polymers - intrinsic and extrinsic, doping of polymeric systems, synthesis, processing and testing of conducting polymers, applications and recent advances – electroluminescence, corrosion inhibition, microelectronics, membranes, sensors, textiles, electro-chemomechanical devices, coating etc.

UNIT III HEAT AND FIRE RESISTANT POLYMERS 9

Combustion of polymeric materials and methods to reduce it, requirements for heat resistance, determination of heat resistance, synthesis, structure-property relationships, fire retardant fillers, applications of heat resistant polymers like polyamides, polyimides and its derivatives, polyquinolines, polyquinoxalines, PBT, PBO, PBI, PPS, PPO, PEEK, chlorinated polymers, engineering plastic blends.

UNIT IV SMART AND MISCELLANEOUS POLYMERS 9

Introduction to smart polymers, temperature responsive polymers, pH responsive polymers, photo responsive polymers, magnetically responsive polymers, enzyme responsive polymers, shape memory polymers, hydrogels, self-healing polymers.Applications of smart polymers in various fields such as drug delivery, tissue engineering, medical devices, bioseparation, optical data storage, packaging and textiles etc.

Macromolecules as catalysts, information transmitting polymers, reactive polymers, magnetic polymers, luminescent polymers, ion conducting polymers, high performance fibers, dendritic polymers, inorganic polymers, ionic polymers, hydrogels.

UNIT V BIOPOLYMERS AND BIODEGRADABLE PLASTICS 9

Biopolymers - Study of biopolymers and their applications, like bioassays, biocatalysts, etc., need of biomaterials and biopolymers, biodegradation, overview of biodegradable polymers, degradation study, factor affecting biodegradability, classification – natural, synthetic, modified, starch based, PHAs, PLA, synthetic biodegradable polymers- PBS, PCL, PGA, etc., environmental impact, biomaterials and their 16 medical applications, control release theory, scaffold materials, orthopedic applications, rehabilitation aids, etc., ASTM methods of testing.

TOTAL: 45 PERIODS

OUTCOME

Upon completion of this course, the students

- Will familiarize about advance polymeric materials and its application.
- Will develop the knowledge in the mechanism of preparation of materials
- Will acquire the skill in assessing the biopolymer and bio-degradability of polymers

REFERENCE BOOKS

1. Additive for coatings, John Bieleman, Wiley-VCH, 2000
2. Additives in waterborne coatings, Gerry Davison, Bruce Lane, Royal society of Chemistry, 2003
3. Encyclopedia of Polymer science and Engineering Vol.1-17, Jacqueline I. Kroschwitz, 2007.
4. Engineering Polymers; R.W. Dyson, Chapman and Hall, New York, 1990
5. Fire Properties of Polymeric Composites Materials, A.P. Mouritz, A G. Gibson, Springer, 2006.
6. Modern Biopolymers science: Bridging the divide between fundamentals treatise and industrial application, Stefan Kasapis, Ian T. Nortan, Johan B Ubbink, Elsevier Inc., 2009.
7. Polymers for High Technology Electronics and Photonics; M.J. Bowden and S.R. Tumer, Amer. Chem. Soc., 1987
8. Recent Advances in Liquid Crystalline Polymers; L. Lawrence Chapoy, Ed. Elsevier Science, New York, 1985

PO5071 THERMOPLASTIC ELASTOMERS L T P C
3 0 0 3

OBJECTIVE

- To understand about the different methods of synthesising TPEs and advantages over thermoplastics and elastomers
- To provide a comprehensive overview of different TPEs based on polyolefin, vinyl, styrenic, urethane and polyamides
- To familiarise the student about structure , properties and applications of different TPEs

UNIT I CLASSIFICATION OF THERMOPLASTIC ELASTOMERS 9

Introduction to Thermoplastic Elastomers (TPE) Polyolefin – based thermoplastic elastomers – Block copolymer, Random Block polymers, Graft copolymers, Polyolefin blend TPE's preparation, Properties, processing and applications.

UNIT II THERMOPLASTIC ELASTOMERS FROM CONVENTIONAL POLYMERS 9

Polyvinylchloride based Thermoplastic Elastomers – PVC/Nitrile Rubber blends, PVC/Polyurethane blends. Styrenic Thermoplastic Elastomers – Manufacture, Properties Applications.

UNIT III POLYURETHANE ELASTOMER 9

Thermoplastic Polyurethane Elastomer – Raw materials, Synthesis, Properties, Processing, Blends and Applications.

UNIT IV POLYAMIDE AND POLYETHER BASED ELASTOMER 9

Polyamides based Thermoplastic Elastomers – Polyamide thermoplastic elastomers, Preparation, properties, and applications. Thermoplastic Polyether ester Elastomers – Synthesis, Properties and applications.

UNIT V THERMO PLASTIC ELASTOMER FROM BLENDS 9

Introduction - Preparation of Elastomer – Plastic blends by dynamic vulcanization, properties and applications. Ionomeric Thermoplastic Elastomers: Synthesis, Properties, and applications of ionomeric elastomers

TOTAL : 45 PERIODS

OUTCOME

At the end of the course, the student should be able to

- differentiate the unique characteristics of different TPEs compared with thermoplastics and elastomers
- be able to select the suitable TPE for the application
- be able to Correlate the structure and properties of different TPEs

REFERENCES

1. Anil K. Bhowmick, Howard L. Stephens, Hand Book of Elastomers New Developments and Technology, Marcel Dekker, Inc., New York, 1988.
2. Benjamin M. Walker, Hand Book of Thermoplastic Elastomers, Van Mostrand Reinhold Company, New York, 1979
3. G.Holden, N.R. Legge, R. Quirk, H.E. Schrolder, Thermoplastic Elastomers – 2nd Edition, Hanser Publishers, Munich, 1996.
4. S.K. De, Anil K. Bhowmick, Thermoplastic Elastomers from Rubber – Plastic Blends, Ellis Horwood, New York, 1990.

PO5072 POLYMER NANOCOMPOSITES L T P C

3 0 0 3

OBJECTIVES

- To gain an understanding of materials commonly used for nano-modification such as nanoclays, carbon nanotubes, etc.

- To study different manufacturing techniques of dispersion of nano particles such as sonication, high shear mixing, centrifugal mixer, twin-screw extrusion.
- To study different manufacturing techniques to produce real-life components
- To understand characterization techniques of these materials using scattering, spectroscopic and microscopic techniques

UNIT I **9**

Definition of nanocomposite, nanofillers, classification of nanofillers, carbon and noncarbon based nanofillers- synthesis and properties of fillers.

UNIT II **9**

Properties of various polymer nanocomposites: Nanotube/Polymer Composites, Layered Filler Polymer Composite Processing- Polyamide Matrices, Polyimide Matrices, Polypropylene and Polyethylene Matrices, Liquid-Crystal Matrices, Epoxy and Polyurethane Matrices, Rubber Matrices.

UNIT III **9**

Synthesis of Nanocomposite: Direct Mixing, Solution Mixing, In-Situ Polymerization, In-Situ Particle Processing Ceramic/Polymer Composites, In-Situ Particle Processing Metal/Polymer Nanocomposites, Modification of Interfaces, Modification of Nanotubes, Modification of Nanoparticles. Surface treatment, Composites manufacturing techniques.

UNIT IV **9**

Characterization of Nanocomposites: 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).

Properties of Nanocomposite: Mechanical Properties, Modulus and the Load-Carrying Capability of Nanofillers, Failure Stress and Strain Toughness, Abrasion and Wear Resistance, Permeability, Dimensional Stability Contents, Thermal Stability and Flammability, Electrical and Optical Properties, Resistivity, Permittivity, and Breakdown Strength, Refractive Index, Barrier properties of polymer nanocomposites, Permeation and diffusion models relevant to polymer Nanocomposites, Polymer nanocomposites diffusivity, sorption, permeability. Wear resisting polymer nanocomposites: preparation and properties, Wear performance and mechanisms.

UNIT V **9**

Nanocomposites containing functionalized nanoparticles: Organic and polymer materials for electronics devices such as LED, Photo-voltaics etc.,- Polymer Nanocomposites for Bio-medical application, Photo-oxidation of polymers, Nanoparticles approaches to enhance the lifetime of polymers

TOTAL: 45 PERIODS

OUTCOMES

At the end of the course, the student should be able to

- The student will Know different characterization and testing techniques and interpretation of results
- The student will have a knowledge about different structures and properties of nanocomposites

- The student will have an idea about preparation technologies and applications of nanocomposites

REFERENCES

1. Joseph H. Koo, Polymer Nanocomposites, Processing, Characterization, and Applications, McGraw-Hill 2006
2. L.A. Utracki " Clay-Containing Polymeric Nanocomposites" Rapra Technology Limited, 2004
3. Luigi Nicolis& Gianfranco Carotenuto "Metal -Polymers Nanocompsites" A John Wiley & Sons, Inc Publication 2005
4. P. M. Ajayan, L. S. Schadler, P. V. Braun (Eds) Nanocomposite Science and Technology WILEY-VCH Verlag GmbH Co. KGaA, Weinheim, 2003
5. Y.C. Ke& P. Stroeve " Polymer-Layered Silicate and Silica Nanocomposites- Elsevier, 2005

PA5009 SECONDARY PROCESSING TECHNIQUES L T P C
3 0 0 3

OBJECTIVES:

- To know about the different processing methods like calendaring, thermoforming, and rotomoulding.
- To gain knowledge about the processing of FRP laminates.
- To understand the various machining and joining method for plastics products.

UNIT I CALENDERING, THERMOFORMING AND ROTOMOULDING 9

Calendering: Introduction – type of calenders – roll configuration – Definition of terms such as calender bank – calendering process – process variable and application.

Thermoforming: Introduction – pressure forming – vacuum forming – Techniques of vacuum forming – simple vacuum forming, drape forming, plug assisted forming, snapbackvacuum forming – pressure snap-back forming-blow back forming – merits &demerits of vacuum forming – vacuum forming moulds. Pressure forms – Advantages over vacuum forming – material for thermo forming – heating systems. Matched deforming – continuous forming methods – application.

UNIT II FRP LAMINATES 9

Introduction, FRP processing methods – contact moulding – hand lay up, spray up method– vacuum bag & pressure bag moulding, filament welding, centrifugal casting, pultrusion,matched die moulding – Laminates, definition of terms – high, pressure laminating process, types of machinery, impregnation systems – decorative and industrial laminates, continuous high pressure laminating process, application.

UNIT III CELLULAR PLASTICS 9

Introduction – process to create foam in resins – mechanical foaming, chemical foaming, physical foaming – processes to shape and solidify foams – low pressure foam moulding, high pressure foam moulding, RIM extrusion foaming, casting foams, steam chest moulding structural foam moulding – applications.

UNIT IV MACHINING& JOINING OF PLASTICS 9

Introduction – Importance of machining – methods viz. cutting, drilling, blending, filling,etc. Joining – principles – cohesion principle, adhesion principle – solvent cementing, Dop cementing, welding

of plastics – viz. high frequency welding thermal sealing, spin welding,vibration welding, hot plate welding, ultrasonic welding, Adhesive bonding – examples:Mechanical fasteners.

Other Secondary Processes: Printing, painting, Hot stamping, In mould decoration,Electro plating and vacuum metallising.

UNIT V CASTING PROCESSES AND ROTATIONAL MOULDING 9

Dip casting, slush casting, continuous casting, cell casting, processes and applications.Introduction – principle – process – machinery used – materials – moulds, process parameters – merits & demerits of rot moulding.

Coating Processes: Roller coating, powder coating, fluidised bed coating, electrostatic spray coating, processes and applications.

TOTAL : 45 PERIODS

OUTCOME:

- Ability to select a specific processing technique as per the requirement.
- Ability to choose a machining and joining method of plastic products.

REFERENCES

1. A.Brent Strong, Plastics: Materials and Processing Practice – Hall, New Jersey, 1996.
2. Basic Principle of Rotational Molding - By Bruins.
3. Basic Principle of rotational molding - By Crawford, R.J & Throne, J.L.
4. Basic Principle of Thermoforming - By Brycle, D.M
5. Compression Moulding - By Iyesew, A.I.
6. Extrusion The definitive Processing Guide and Hand Book - By Giles, H.H & Others.
7. Injection molding of Plastics component - By Bown John.
8. Injection Moulding - By Athalye, A.S.
9. Injection Moulding Technology - By V.D.I.
10. Innovation in Polymer Processing - By Stevenson.
11. M.N. Watson, Joining Plastics in Production, The Welding Institute, Cambridge, 1988.
12. Michael L. Berins, SPI Plastics Engineering Handbook.
13. Plastics Injection Moulding - By Brycle, D.M.
14. Plastics Materials & Processing - By Schwartz & Goodman.
15. Plastics Mold Design Vol.1 Compression & Transfer Moulds - By Bebb.
16. Polymer Extrusion - By Rauwedaal, Chris.
17. Thermoforming - By James & Throne.

PA5010 ADDITIVE MANUFACTURING IN PLASTICS PRODUCTS LT P C

3 0 0 3

OBJECTIVE

- To educate students with fundamental and advanced knowledge in the field of Additive manufacturing technology for plastics product
- To learn the fundamentals process of additive manufacturing process.

UNIT I 9

Introduction to Additive Manufacturing (AM)- AM evolution, Distinction between AM & CNC machining, Advantages of AM; AM process chain: Conceptualization, CAD, conversion to STL, Transfer to AM, STL file manipulation, Machine setup, build, removal and clean up, post processing; Classification of AM processes: Liquid polymer system, molten material systems, discrete particle system, solid sheet system.

UNIT II **9**

Stereolithography Apparatus (SLA): Principle, pre-build process, part-building and post-build processes, photo polymerization of SL resins, Advantages, limitations and applications; Solid Ground Curing (SGC): Principle, process, Advantages, limitation, and applications; Fused deposition Modeling (FDM): Principle, details of processes Advantages, limitation, and applications; Laminated Object Manufacturing (LOM): Principles, details of processes, products, materials, advantages, limitations and applications;

UNIT III **9**

Selective Laser Sintering (SLS): Principle, process, Indirect and direct SLS- powder structures, materials, post processing, surface deviation and accuracy, Applications; Laser Engineered Net Shaping (LENS): Processes, materials, products, advantages, limitations and applications. Other Additive Manufacturing Systems: Shape Deposition Manufacturing (SDM), Ballastic Particle Manufacturing (BPM), Selective Laser Melting, Electron Beam Melting;

UNIT IV **9**

Design for AM: Motivation, DFMA concepts and objectives, AM unique capabilities, exploring design freedoms, Design tools for AM, Part Orientation, Removal of Supports, Hollowing out parts, Inclusion of Undercuts and Other Manufacturing Constraining Features, Interlocking Features, Reduction of Part Count in an Assembly, Identification of markings/ numbers etc;

UNIT V **9**

AM Applications: Functional models, Pattern for investment and vacuum casting, Medical models, art models, Engineering analysis models, Rapid tooling (Direct and Indirect method), new materials development, Bi-metallic parts, Re-manufacturing. Application examples for Aerospace, defense, automobile, Bio-medical and general engineering industries;

Post processing of AM parts: Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non-thermal and thermal techniques.

TOTAL: 45 PERIODS

OUTCOMES

Upon completing this course, the students will have an

- Ability to choose a suitable Additive Manufacturing (AM) method.
- Ability to face the research challenges associated with AM and its data processing tools

REFERENCES

1. Andreas Gebhardt, Understanding Additive Manufacturing: Rapid Prototypying, Rapid Tooling Rapid Manufacturing.
2. Chua, C.K., Leong K.F. and Lim C.S., “Rapid prototyping: Principles and applications”, second edition, World Scientific Publishers, 2010
3. Gibson, I., Rosen, D.W. and Stucker, B., “Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing”, Springer, 2010
4. Kamrani, A.K. and Nasr, E.A., “Rapid Prototyping: Theory and practice”, Springer, 2006.

PA5011 BIOPOLYMERS AND BIO COMPOSITES L T P C
3 0 0 3

OBJECTIVES

- To learn about various types of biopolymers produced from starch and microbes.
- To know about the various bio-based feed stocks for biopolymers.
- To learn about different types of natural fibers and their surface treatments.
- To learn about different types of thermoset and thermoplastic bio composites and their characterization

UNIT I BIOPOLYMERS 9

Recent Development in the Bio-Polymer Industry - starch based materials, Plant Produced Polymers, Microbially produced polymers, Biologically-Based resins, Adhesives, and coatings, continuing research and development on Bio-polymers.

UNIT II NATURAL FIBERS 9

Bastfibers (Jute, Flax, Ramie,hemp, Kenaf)-Seed fibers (Cotton, Coir and Kapok)-Leaf fibers (Sisal,Pineapple and Abaca) -Grass and reed fibers (rice, corn and wheat)-Wood fibers-Different surface treatments-alkali-silane-isocyanate – benzoylation-acrylation, etc

UNIT III THERMOSET BIOCOMPOSITES 9

Thermosets-Thermoset Natural fiber composites-Fabrication techniques-Hand layup-press moulding-Filament winding-Pultrusion – bag moulding-filament winding-pultrusion-Case studies-Jute-thermoset-Coir thermoset-Sisal-thermoset-Pineapple leaf fiber-thermoset-Banana fiber-thermoset biocomposites.

UNIT IV THERMOPLASTIC BIOCOMPOSITES 9

Thermoplastics-Thermoplastic Natural fiber composites-Fabrication techniques-Long fiber-Short fiber technology-Case studies-Jute-thermoplastic-Coir thermoplastic-Sisal-thermoplastic-Pineapple leaf fiber-thermoplastic-Banana fiber-thermoplastic bio composites

UNIT V CHARACTERISATION OF BIOCOMPOSITES 9

FTIR-Fiber–resin surface tension and interfacial adhesion-Viscoelastic properties-Rheological properties-Mechanical-Thermal-Morphology-Flammability.

TOTAL : 45 PERIODS

OUTCOME

- Students understand production of bio-plastics from bio-based feed stocks.
- Learn about various natural fibers.
- Understand the different types of thermoset and thermoplastic bio composites and their characterization.

REFERENCES

1. Amar K Mohanty, Manjusri Mishra and Lawrence T.DrzalNatural fibers, biopolymers and biocomposites, CRC press (2005)
2. Joon B. Park and Roderic S. Lakes, Biomaterials: An Introduction, 2nd edition, Plenum Press, New York (1992).
3. Seeram Ramakrishna, Zheng-Ming Huang, Ganesh V Kumar and Andrew W Batchelor, An introduction to biocomposites, Imperial college press (2004)
4. TatsukoHatakeyama and HyoeHatakeyama, Thermal properties of green polymers and biocomposites, Springer (2004)

5. Visakh P.M and Sigrid Luftl, Polyethylene based biocomposites and nanocomposites, John Wiley & Sons (2016)

PA5071 POLYMER RECYCLING L T P C
3 0 0 3

OBJECTIVES

- To emphasize the fundamentals and importance of plastics recycling.
- To impart the knowledge on various sorting and separation techniques.
- To highlight recycling procedures for commodity and engineering plastics.
- To familiarize rubber recycling procedures.

UNIT I FUNDAMENTALS OF PLASTICS RECYCLING 9

Need for recycling –Source of Plastic waste – depolymerization - Thermal depolymerization – Ceiling temperature and its importance – Degradation – Biodegradation, Primary, Secondary and Tertiary recycling.

UNIT II RECYCLING OPERTIONS 9

Sorting and separation techniques – Density based – Optical sorting – Electrostaticsorting – Sorting by melting temperature – Sorting by selective dissolution- sorting of metalcontaminants, size reduction - cutting – Densification – Pulverization – Chemical methods,melt filtration of contamination in recycled plastics – screen changers – filtration requirementsof different recycled plastics.

UNIT III RECYCLING MATERIALS- I 9

Recycling of PET – PET separation – Melt reprocessing – Chemical reprocessing – Energy recovery – application.HDPE recycling – Application of HDPE recyclate – LDPE recycling – Application of LDPE recycle LDPE – film recycling – Polypropylene recycling – Application of recycled PP – Recycling of polystyrene - Application of Recycled EPS.Nylon recycling – Chemical recycling – Mechanical recycling – applications Depolymerization of PMMA.

UNIT IV RECYCLING MATERIALS- II 9

Recycling of Engineering Thermoplastics – PC – ABS Mechanical and chemical recycling of polyacetals – Uses, recycling of polyurethanes – Physical methods – Chemical methods, Feed stock recycling and energy recovery.

Recycling of Thermoset composites – grinding of SMC – selective chemical degradation of SMC scrap – solvent recycling – pyrolysis – Energy recovery from SMC scrap – Recycling of thermoplastics composites.Recycling of PVC - Separation techniques for PVC and PET – size reduction – melt filtration – Mechanical recycling – chemical recycling – Energy recovery – applications. Feed Stock Recycling – Pyrolysis – kiln / Retort – Fluidized bed – application – Hydrogenation of plastics waste – Gasification – different gasification process – economic aspects – Incineration of plastic waste with energy recovery.

UNIT V RUBBER RECYCLING 9

Tyre size reduction – Application of ground Rubber crumb – Filler – Bound Rubber products – Thermoplastics binder – Civil engineering applications – Surface treated crumb rubber – applications – Rubber reclaiming and devulcanization scrap rubber and fuel source (Tyre derived fuel TDF) – Pyrolysis.

TOTAL : 45 PERIODS

OUTCOMES

Students will able to:

- Apply the principles of various methods of recycling and to relate the methods tovarious polymeric materials.
- Understand the need for recycling and classification of recycling methods.
- Sort and separate mixed plastics.
- Recycle domestic and engineering thermoplastics.
- Acquire the knowledge of various techniques for rubber recycling

REFERENCES

1. Ann Christine Albertson and Samuel J Huang, Degradable Polymers, Recycling andPlastics, Marcel Dekker Inc, 1995.
2. Gerald D Andrews and Pallatheri M Subramanian, Emerging Technologies in PlasticsRecycling, ACS Symposium Series, 513, 1992.
3. John Scheirs, Polymer Recycling Science, Technology and Applications, JohnWiley&Sons, 1998.
4. Mustafa.N. Plastics Waste Management Disposal Recycling and Reuse, Marcel DekkerInc, 1993.
5. Randall Curlec, T. and Sujit Das, Plastics Wastes: Management Control, Recycling andDisposal, US Environmental Protection Agency, Noyes Data Corporation, 1991.

PA5012 ADVANCED MOULD MANUFACTURING TECHNOLOGY L T P C

3 0 0 3

OBJECTIVES:

- To impart knowledge on various Cutting Tools and CNC Machines
- To develop the knowledge on elements of the mould and manufacturing processes with CAD/CAM/CAE.
- To learn the application of additive manufacturing in mould development
- To acquire skills in advanced measuring instruments for inspection of mold

UNITI CNC MACHINING CENTERS 9

Introduction to CNC Machining Center-Classification-Working Principle and Construction-coordinate system-Dimensioning method-Cutter radius and length compensation– Interpolations-Preparatory and miscellaneous functions–Cutting Tools-Types, Materials and Selection–Cutting parameters-Tool holding devices–Work holding devices–work piece alignment& datum setting–Part programming-types, cycles–CAM Programming–Execution of NC file- Manufacturing of mould elements with CAD/CAM

UNITII CNC TURNING CENTERS 9

Introduction to CNC Turning Center-Classification-Working Principle and Construction-coordinate system-Dimensioning method –Tool Nose radius and length compensation– Interpolations-Preparatory and miscellaneous functions–Cutting Tools-Types, Materials and Selection–Cutting parameters-Tool holding devices–Work holding devices–work piece alignment & datum setting–Part programming-types, cycles–CAM Programming–Execution of CNC file- Manufacturing of mould elements with CAD/CAM

UNITIII CNC DIESIN KING EDM AND WIRE EDM 9

CNC DIESIN KING EDM: Introduction-Theory of metal removal-Working Principle and Construction–Process parameters–Electrode materials and selection-Electrode Design-Dielectric fluid–Functions, requirements and properties-Factors affecting Metal Removal Rate –Applications, advantages and disadvantages–Programming and Manufacturing of mould elements.

CNC Wire EDM : Introduction-Working Principle and Construction–Process parameters–specification and selection of Tool (Wire)—Dielectric fluid–Functions, requirements and properties-Factors affecting cutting process–Applications, advantages and disadvantages-comparison of EDM and wire EDM– Programming and Manufacturing of mould elements.

UNIT IV RAPID TOOLING 9

Introduction to Additive manufacturing-Difference between rapid tooling & conventional tooling – Development of mould elements with RP-conformal cooling of mould elements–silicon moulds for Vacuum Casting-Epoxy Tooling System-Parts in Minutes–Composite tooling board–-Applications, advantages and disadvantages of rapid tooling.

UNIT V ADVANCESINMETROLOGY 9

Co-ordinate measuring machine–Constructional features–Types–Applications of CMM– CNC CMM applications–Computer Aided Inspection–Machine Vision-Form Measurement– Straightness, Flatness and roundness –Nano metrology –Introduction–Principles–Nano meter metrology systems–Methods of measuring length and surfaces to nano scale result with interferometers and other devices.

TOTAL : 45PERIODS

OUTCOMES:

Upon completing this course, the students

- Ability to apply the knowledge in CNC Machine Tools for mould manufacturing
- Ability to select 3 D printing and rapid tooling techniques.
- Ability to use advanced measuring equipment for inspection of mold

REFERENCES

1. HMT Production Technology, TMH (India),1992
2. Jain R K," Engineering Metrology" , 19thEdition , Khanna Publishers ,2005
3. Klus Stokhert (Edt.), Mold making handbook for Plastic Engineers, Hanser Publishers, NY,1983
4. Peter Jones, "The Mould Design Guide", SmithersRapraTechnologyLtd.,2008

PA5072 TOTAL QUALITY MANAGEMENT L T P C

3 0 0 3

OBJECTIVES

- To provide comprehensive knowledge about the principles, practices, tools and techniques of Total quality management

UNIT II NTRODUCTION 9

Introduction – Need for quality – Evolution of quality – Definitions of quality – Dimensions of product and service quality – Basic concepts of TQM – TQM Framework – Contributions of Deming, Juran and Crosby – Barriers to TQM – Quality statements – Customer focus – Customer orientation, Customer satisfaction, Customer complaints, Customer retention – Costs of quality.

UNIT II TQM PRINCIPLES 9

Leadership – Strategic quality planning, Quality Councils – Employee involvement – Motivation, Empowerment, Team and Teamwork, Quality circles Recognition and Reward, Performance appraisal – Continuous process improvement – PDCA cycle, 5S, Kaizen – Supplier partnership – Partnering, Supplier selection, Supplier Rating.

UNIT III TQM TOOLS AND TECHNIQUES-I 9

The seven traditional tools of quality – New management tools – Six sigma: Concepts, Methodology, applications to manufacturing, service sector including IT – Bench marking – Reason to bench mark, Bench marking process – FMEA – Stages, Types.

UNIT IV TQM TOOLS AND TECHNIQUES-II 9

Control Charts – Process Capability – Concepts of Six Sigma – Quality Function Development (QFD) – Taguchi quality loss function – TPM – Concepts, improvement needs – Performance measures.

UNIT V QUALITY SYSTEMS 9

Need for ISO 9000 – ISO 9001-2008 Quality System – Elements, Documentation, Quality Auditing – QS 9000 – ISO 14000 – Concepts, Requirements and Benefits – TQM Implementation in manufacturing and service sectors.

TOTAL: 45 PERIODS

OUTCOMES

- To under the various principles, practices of TQM to achieve quality To learn the various statistical approaches for quality control.
- To understand the TQM tools for continuous process improvement. To learn the importance of ISO and Quality systems

REFERENCES

1. Dale H. Besterfiled, et at., “Total quality Management”, Pearson Education Asia, Third Edition, Indian Reprint, 2006.
2. James R. Evans and William M. Lindsay, “The Management and Control of Quality”, 8th Edition, First Indian Edition, Cengage Learning, 2012.
3. Janakiraman. B and Gopal .R.K., “Total Quality Management – Text and Cases”, Prentice Hall (India) Pvt. Ltd., 2006
4. Suganthi.L and Anand Samuel, “Total Quality Management”, Prentice Hall (India) Pvt. Ltd., 2006.

PA5013 BIO-MEDICAL PLASTICS L T P C

3 0 0 3

OBJECTIVES

- To learn about various types of biopolymers produced from starch and microbes. To understand various natural and synthetic polymers used for biomedical applications.
- To learn about the plastics that are used as implants in cardiovascular, dental, ophthalmology, and other artificial organs.
- To be familiarized with evaluation methods of biomedical polymers and their interaction with human system in in-vivo and in-vitro environments.

UNIT I BIOPOLYMERS 9

Recent Development in the Bio-Polymer Industry - starch based materials, Plant Produced Polymers, Microbially produced polymers, Biologically-Based resins, Adhesives, andcoatings, continuing research and development on Bio-polymers

UNIT II SYNTHETIC AND NATURAL BIOMATERIALS 9

Polyolefin's, Polyamides, Acrylic Polymers, Fluorocarbons, Polyesters, Engineering Plastics. Collagen, Polysaccarides, Proteins, etc.

UNIT III MEDICAL APPLICATIONS OF PLASTICS 9

Cardiovascular implants, Dental Implants, Role of plastics in Ophthalmology, Hydro gels,Drug Delivery systems, Sutures, Burn Dressings and Artificial skin, Hernia Mesh,Adhesives and Sealants, Artificial organs and devices, Blood bags, Condoms, etc.

UNIT IV POLYMER INTERACTIONS AND BIO DEGRADATION 9

Interaction with blood and blood compatibility, chemical and biochemical degradation ofpolymers, Tissue engineering and polymers.

UNIT V TESTING AND EVALUATION 9

in-vitro/vivo; Standards in product development and regulations; Ethical and sociologicalissues.

TOTAL: 45 PERIODS

OUTCOME

- Students understand production of bio-plastics from bio-based feed stocks. They learn about various plastics that are used for biomedical applications such as cardiovascular, dental, ophthalmology, and other artificial organs. Students also understand the methods and standards used for the evaluation of biomedicalpolymers.

REFERENCES:

1. Buddy D. Ratner, Allan S. Hoffman, Fredrick, J. Schoen and Jack E. Lemons (Eds),Biomaterials, Science – An Introduction to Materials in Medicine, Academic Press, SanDiego (1996).
2. Joon B. Park and Roderic S. Lakes, Biomaterials: An Introduction, 2nd edition, PlenumPress, New York (1992).

PO5073 INTELLECTUAL PROPERTY RIGHTS (IPR) AND COPY RIGHT LAWS L T P C

3 0 0 3

OBJECTIVES

- To know about the intellectual properties, patents, trade marks and design rights
- To understand the procedure for applying patent documentation
- To get information on the industrial design and its projection
- To learn about the procedure for commercialization of intellectual properties

UNIT I 9

Introduction – Invention and Creativity – Intellectual Property (IP) – Importance –Protection of IPR – Basic types of property (i). Movable Property - Immovable Property and - Intellectual Property.

UNIT II **9**

IP – Patents – Copyrights and related rights – Trade Marks and rights arising from Trademark registration – Definitions – Industrial Designs and Integrated circuits –Protection of Geographical Indications at national and International levels – Application Procedures..

UNIT III **9**

International convention relating to Intellectual Property – Establishment of WIPO –Mission and Activities – History – General Agreement on Trade and Tariff (GATT) –TRIPS Agreement.

UNIT IV **9**

Indian Position Vs WTO and Strategies – Indian IPR legislations – commitments to WTO-Patent Ordinance and the Bill – Draft of a national Intellectual Property Policy –Present against unfair competition.

UNIT V **9**

Case Studies on – Patents (Basmati rice, turmeric, Neem, etc.) – Copyright and related rights – Trade Marks – Industrial design and Integrated circuits – Geographic indications – Protection against unfair competition.

TOTAL: 45 PERIODS

OUTCOMES

On completion of this paper the student will

- Able to understand the laws and regulation governing the patents, trade marks and copyrights
- Able to know about the procedure for applying patent and copy rights
- Understand the basics of industrial design
- Have detailed knowledge of commercialization of patents and trademarks

REFERENCES

1. Eli Whitney, United States Patent Number: 72X, Cotton Gin, March 14, 1794.
2. Intellectual Property Today: Volume 8, No. 5, May 2001, [www.iptoday.com].
3. Subbaram N.R. “Handbook of Indian Patent Law and Practice “, S. Viswanathan Printers and Publishers Pvt. Ltd., 1998.
4. Using the Internet for non-patent prior art searches, Derwent IP Matters, July 2000.
5. www.ipmatters.net/features/000707_gibbs.html.

PA5014 **INDUSTRIAL ECONOMICS AND COSTING** **L T P C**
3 0 0 3

OBJECTIVES

- To develop the Knowledge about fundamentals of costing.
- To learn about the methods of materials control and pricing.
- To learn about the income tax rules.

UNIT I FUNDAMENTAL PRINCIPLES OF COST ACCOUNTING **9**

Financial and Cost Accounting – Costing – Elements of Cost – Cost centres – Methods &Types of Costing – Advantages of Cost Accounting – Preparation of cost sheet.

UNIT II PURCHASE & STORES ORGANIZATION 9

Purchase of materials – Procedure for purchases – Levels of materials – Economic ordering quantity. Store keeper and his functions – Bincard; Priced Stores Ledger – Perpetual InventorySystem – ABC Method of stores control – Pricing of material issues (FIFO, LIFO, Averageprice, etc.).

UNIT III LABOUR COSTING 9

Methods of recording attendance – Methods of remuneration – Time rate, Differential timerate, payment by results – Different Incentive schemes (Taylors differential, Merrick, GanttTask Bonus, Emerson & Halsey plan).

UNIT IV BUDGETARY CONTROL & MARGINAL COSTING 9

Budget – Budgetary control – Types of Budgets – Advantages & Difference between Budgetary control and Standard costing – Zero base budgeting. Marginal cost & costing – Cost volume profit Analysis – PIV Ratio – Margin of safety –Application of Marginal costing technique – Advantages – Break Even point & Analysis – Its advantages.

UNIT V TAX RULES & REGULATIONS 9

Brief about Income tax Rules, Customs, Excise Rules, Sales Tax & its application in industry.

TOTAL : 45 PERIODS

OUTCOME

1. Ability to understand the costing of a product.
2. Ability to fix materials price, labours incentives.
3. Ability to follow tax rules and regulation.

REFERENCES

1. B.K. Bhar, Cost Accounting Methods and Problems – Academic Publisher, Calcutta,1991.
2. B.M. Lall Nigam, I.C. Jain, Cost Accounting an Introduction – Prentice, Hall of India Pvt.Ltd., New Delhi, 2001.
3. S.P. Jain, K.L. Narang, Cost Accounting Principles and Practice, Kalyani Publishers, New Delhi, Ed. 12, 1993.
4. T. Horngren, M.R. Foster, M.Datar, Cost Accounting A Managerial Emphasis – Prentice,Hall of India Pvt. Ltd., New Delhi, Ed.8, 1994.39