Vocational Higher Secondary Education (VHSE)

Second Year

# POLYMER TECHNOLOGY

*Reference Book - Teachers' Version*

Government of Kerala
Department of Education

State Council of Educational Research and Training (SCERT),
KERALA
2016

# *Foreword*

Dear Teachers

This reference book **(Teachers' Version)** is intended to serve as a transactional aid to facilitate classroom transaction and as a ready reference for teachers of Vocational Higher Secondary Schools. It offers some guidelines for the transaction of the course content and for undertaking the practical work listed in the course content. As the curriculum is activity based, process oriented and rooted in constructivism focusing on the realisation of learning outcomes, it demands higher level proficiency and dedication on the part of teachers for effective transaction.

In the context of the Right- based approach, quality education has to be ensured for all learners. The learner community of Vocational Higher Secondary Education in Kerala should be empowered by providing them with the best education that strengthens their competences to become innovative entrepreneurs who contribute to the knowledge society. The change of course names, modular approach adopted for the organisation of course content, work-based pedagogy and the outcome focused assessment approach paved the way for achieving the vision of Vocational Higher Secondary Education in Kerala. The revised curriculum helps to equip the learners with multiple skills matching technological advancements and to produce skilled workforce for meeting the demands of the emerging industries and service sectors with national and global orientation. The revised curriculum attempts to enhance knowledge, skills and attitudes by giving higher priority and space for the learners to make discussions in small groups, and activities requiring hands-on experience.

The SCERT appreciates the hard work and sincere co-operation of the contributors of this book that includes subject experts, industrialists and the teachers of Vocational Higher Secondary Schools. The development of the teachers' version of reference books has been a joint venture of the State Council of Educational Research and Training (SCERT) and the Directorate of Vocational Higher Secondary Education.

The SCERT welcomes constructive criticism and creative suggestions for the improvement of the book.

With regards,

**Dr. J. Prasad**
Director
SCERT, Kerala

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# About the course

Vocational Higher Secondary Education in Kerala is a unique scheme of education which combines both vocational and academic stream of education. Learning vocational skills along with conventional academic education gives the students double advantage of vertical mobility as well as employability. It helps to develop vocational aptitude, work culture, values and attitudes of the learner and enhances his productivity. The vision of Vocational Higher Secondary Education in Kerala is to equip the youth with multiple skills matching the technological advancements and to produce skilled work force for meeting the demands of the emerging industries and service sectors with national and global orientation.

As India is emerging as a manufacturing hub to the world the demand for skilled manpower is on the rise. Kerala, traditionally known for its high quality man power all over the world can embark on this opportunity and equip our students with skills for the manufacturing sector and reduce the unemployability problems of the state.

The polymer technology course in VHSE is one such course from the manufacturing sector. Polymers have wide spread applications in our daily life like simple household articles, automobiles, spacecrafts, medical products etc and is rapidly replacing many conventional materials like metals in many applications. Hence acquiring skills in the manufacturing of polymer products will help the students to get early employment opportunities.

The course is designed for providing knowledge and skills to participants in Rubber, Plastics, and Composite products manufacturing. This course is offered in modular format consisting of four modules with focus on multi skills development. One month On the Job Training and Production cum training centres are also an integral part of the course which gives exposure to real time work environment. Upon successful completion of this course the candidate will be able to join Rubber/plastic/composite industries as junior level technicians and are also eligible for attending advanced courses on Polymer Technology or any other courses that can be pursued after plus two science stream

# Job roles

Polymers are all around us from simple house hold articles and clothing materials to automobile, aircraft, to medical products, making it impossible to live without polymers. The polymer industry in India employs nearly 12 lakh peoples and is growing at a rate of 15 – 16% CAGR. As the per-capita consumption of polymers in India is far below the global average, the industry will continue to show robust growth in the next 10 – 15 years. This will create millions of job opportunities in polymer industries at all levels.

"Polymer Technology course explore different polymeric materials, their properties, important application and processing to make final products.

VHSE course in Polymer Technology provide candidates with hands-on and theoretical knowledge that provides them an excellent platform for further studies as well as prepares them for technician-level jobs in the rubber/plastics and composite industries. This is a great opportunity to learn in-demand job skills.

| Government sector | Private sector | Self employment |
|---|---|---|
| 1. Lab assistant - VHSE<br>2. Trades man - Polytechnic<br>3. Technical assistant - Rubber Board<br>4. Technical assistant CFSC<br>5. Lab technician Plantation corporation<br>6. Production Assistant – Hindustan Latex ltd.<br>7. Lab Technician – Rubber<br>8. Lab Technician – Plastics<br>9. Lab Technician - composites<br>in VSSC, SCTIMST, Defense Laboratories, CSIR – research laboratories | 1. Rubber processing technician<br>2. Chemical weigher<br>3. Junior technician<br>4. Lab technician<br>5. QC inspector<br>6. Rubber molding technician<br>7. Rubber Extruder operator<br>8. Plastic processing technician<br>9. Injection molding machine operator<br>10. Extruder operator<br>11. Blow molding machine operator<br>12. FRP (Fibre reinforced plastics) processing technician | 1. Latex product manufacturing(Gloves, finger cap, rubber band, toys, catheter)<br>2. Rubber molded goods manufacturing<br>3. Tyre retreading<br>4. Plastic processing unit.<br>5. Injection molding unit<br>6. Extrusion unit<br>7. Blow molding unit<br>8. Fibre glass processing (FRP doors, biogas plant, helmet etc) |

**Major skills (with sub skills)**

**Module – I**

1) Polymer processing skills
    a. Identify the materials and processes in plastic and rubber processing
    b. Identify and weigh different materials as per the formulations within the weight tolerance range.
    c. Setting and operation of Hand/Semi automatic injection molding machines.
    d. Setting and operation of Compression molding hand press

**Module – II**

1) Natural rubber crop processing
    a. Processing of Latex into different marketable forms such as Centrifuged/creamed latex, RSS, Crepe Rubber, and TSR.
2) Latex product manufacturing
    a. Manufacture of latex dipped products such as gloves, balloons.
    b. Manufacture of latex threads and latex forms
3) Dry rubber products manufacturing
    a. Preparation of rubber compounds
    b. Manufacture of rubber molded goods
    c. Manufacture of extruded and calendered rubber products
    d. Manufacture of tyres and tubes
4) Testing and quality control in rubber industry
    a. Testing of raw rubbers, latex, and rubber compounds

**Module – III**

1) Plastic processing
    a. Setting and operation of Injection molding machines
    b. Setting and operation of blow molding machines
    c. Production of extruded plastic products
    d. Production of rotational molded plastic products
    e. Production of thermoformed and calendered plastic products
2) Plastic testing
    a. Testing of plastic materials and products

**Module – IV**

1) FRP Processing
    a. Identification of different materials used in the making of fibre reinforced composites.
    b. Manufacture of FRP products using different methods such as Hand lay-up, filament winding, pultrusion, etc
2) Observing safety precautions and work instructions

## Learning outcomes of the course

Upon successful completion, the Learners will be able to

- Explain basic Concepts of polymer processing
- List the industrial use of rubber, plastics and composites
- Elaborate on techniques involved in manufacturing of polymer products
- Describe the working of rubber mixing and processing equipments.
- Demonstrate skill in the mixing and molding of rubbers
- Describe the working principles and components of plastic processing machines
- Demonstrate skill in the working of plastic processing machineries.
- Describe the different FRP processing techniques
- Demonstrate the skill in the manufacture of FRP products
- Demonstrate new age practices and methods adopted in industries
- Practice testing of Rubber/plastic compounds & products
- Follow standards & specifications of systems and products
- Follow safety guidelines working instructions

# COURSE STRUCTURE

**This course consists of Four Modules.**

| Module | Title of the Module | No. of Notional /Learning Periods |
|---|---|---|
| **MODULE I** | **BASIC POLYMER PROCESSING** | **340** |
| **MODULE II** | **RUBBER PROCESSING** | **340** |
| **MODULE III** | **PLASTIC PROCESSING** | **340** |
| **MODULE IV** | **FIBRE REINFORCED PLASTIC PROCESSING** | **340** |

# SYLLABUS
# Module – III Plastic Processing

## 3.1 Introduction to Plastic Processing (20 Periods)

Introduction to plastic processing, Different plastic processing techniques. Effect of polymer properties on processing. Moisture absorption, Thermal stability. Important properties, applications and processing parameters of common plastics such as HDPE, LDPE, PP, PS, PMMA, PVC, ABS, SAN,Nylon6, 66, 12, PET, PBT, PC, and POM.

## 3.2 Injection moulding (90 Periods)

Injection moulding process - advantages, disadvantages. Injection moulding machine - lunger type, screw type. Different parts of injection moulding machines and their respective functions. Screw Design - feed, transition and metering zones, L/D ratio, compression ratio. Clamping Systems - Manual clamping, Toggle clamping, Hydraulic clamping, and Tie bar less clamping. Moulds - two plate moulds, three plate moulds. Parts of moulds - Runner - cold runner, hot runner, gate, ejection systems, cooling channels. Process parameters - Shot weight, Barrel residence time, Clamping force, - melt and mould temperatures, screw speed, back pressure, injection pressure and holding pressure, injection speed, holding time, cooling time, mould open time. Moulding cycle. Processing defects, causes, and remedies.

## 3.3 Extrusion (60 Periods)

Plastic extrusion fundamentals, classification of extruder, different parts and its function of screw extruder - feed hopper, extruder barrel and screw, feed, compression and metering zones, screw nomenclature, types of screws - polyolefin, PVC and Nylon screws, dies, screen pack, breaker plate, heating and cooling elements and drive system. Extrusion dies - solid cross section and hollow cross section dies. Sheet extrusion, profile extrusion, pipe extrusion, blown film extrusion, extrusion of cable. Extrudate swell, melt fracture.

## 3. 4 Blow moulding and rotational moulding (60 Periods)

Blow moulding - Different types of blow moulding - extrusion blow moulding, injection blow moulding, stretch blow moulding. Problems and trouble shooting in blow moulding. Rotational moulding - Advantages, disadvantages, Rotational moulding vs. blow moulding, applications. Faults and remedies in rotational moulding.

## 3.5 Thermoforming and calendaring (60 Periods)

Thermoforming, materials for thermoforming, Different forming processes – Vacuum forming, pressure forming, matched mould forming, plug assisted forming, drape forming. Calendaring of plastics. Different types of calenders, gauge control – roll bending, roll crossing, and roll crowning.

## 3.6 Testing of plastics (50 Periods)

Testing of plastics- Need for testing, Specifications and standards, specific gravity, Mechanical - Tensile and flexural properties, Impact strength. Hardness. Thermal - Melt flow Index, Vicat softening point, heat deflection temperature. Environmental stress crack resistance

## Module – IV Fibre Reinforced Composites

### 4.1 Introduction to composites (30 Periods)

Definition of composites, Basic features of composites, Constituents of composites - Matrix, reinforcement and interphase, Advantages, disadvantages and applications of composites. Classification of composites - based on matrix - Polymer matrix,Metal Matrix, Ceramic matrix, based on reinforcement - Fibrous, Flake filled, particulate filled, laminates, sandwiches, Oriented fibre - Uniaxial, Bi axial, Random fibre, Textile, Knitted, Braided.

### 4.2 Reinforcement Fibres (40 Periods)

Functions of reinforcement, requirements of reinforcement fibres, terminology used in fibre science - filament, strand, roving, size, coupling agents, tex, tow, denier, tenacity, drape etc. Forms of reinforcement - Reinforcing mat - Chopped strand mat (CSM), continuous filament mat, veil, woven roving/fabric. Glass fibres - E-Glass, S-Glass, C-Glass, Carbon fibre, Aramid fibre, Boron fibre, UHMWHDPE, Natural fibres - Flax, Hemp, Jute, and Sisal

### 4.3 Matrix Materials and additives (60 Periods)

Functions of matrix, Thermosets and thermoplastics, Polyester resins, Epoxy resins, Phenolic resins, Vinyl ester resins. Curing reactions, gelation and gel time, cure time, reaction rates. Catalyst or initiators - MEKP, Benzoyl Peroxide, Accelerators - cobalt naphthenate, Inhibitors- Tertiary Butyl Catechol, Curing agents - Amines, anhydrides, Fillers - Calcium carbonate, Talc, Clay, Silica, mineral fillers, Pigments and dies, Lubricants, UV stabilizers, Anti static agents, heat stabilizers, Colorants. Release agents and sealing compounds, Coupling agents. Core materials, Gel coats.

### 4.4 Manufacturing Methods (140 Periods)

Introduction, Classification of FRP Manufacturing methods, Open mould processes - Hand lay-up, Spray lay-up, Filament Winding. Closed mould processes - Compression moulding - Dough moulding compound (DMC), Sheet moulding. Compound (SMC) and prepregs, Vacuum bag moulding, Pressure bag moulding, autoclave moulding, Injection moulding, Resin transfer moulding, Vacuum assisted resin infusion moulding. Continuous processes - Pultrusion, Braiding.

### 4.5 Quality and safety in FRP processing (70 Periods)

Storage of raw materials, Workshop conditions - Reinforcement preparation area, Compounding and mixing area, Mould preparation and moulding area, finishing area. Process care - Curing reaction, gel time, hardening time, maturing time, hot cure, cold cure, resin to glass ratio, degree of cure. Mould care. Preparation of moulds, Repair of composites - repair of gel coat layer, filling dents and cracks.

## List of Practical

## Module – III, plastic processing

1) Preparation of plastic compound pellets
2) Work practice on hand injection molding machine
3) Work practice on semi automatic/automatic injection molding machine
4) Production of injection molded products
5) Work practice on plastic extruder machine
6) Work practice on plastic blow molding machine
7) Production of plastic blow molded products
8) Field visit to plastic blown film extrusion unit
9) Field visit to rotational molding and pipe extrusion unit
10) Determination of Tensile properties of plastics
11) Determination of Flexural properties of plastics
12) Determination of hardness of plastics
13) Determination of Melt Flow Index of plastics
14) Determination of Izod impact strength of plastics

**Module IV Fibre reinforced composites**

1) Identification of different types of composites
2) Identify the different types of fibres used in FRP
3) Identify the different form of reinforcements used in FRP
4) Demonstrate the hardening of resin matrix
5) Study of the curing reaction of polyester resins using different types dosages of catalysts
6) Work practice using hand layup technique
7) Production of FRP products using vacuum infusion
8) Field visit to FRP products manufacturing units
9) Preparation of molds and patterns for FRP processing
10) Determine the cost of FRP products

# Learning Outcomes

# Module – III - Plastic Processing

**Unit – 3.1 - Introduction to plastic processing**

3.1.1 Explain the basic plastic processing techniques such as injection molding, blow molding, extrusion processes

3.1.2 Analyze the influence of polymer properties on the processing of polymers

3.1.3 Describe the properties, applications and processing parameters of common plastics such as HDPE, LDPE, PP, PS, PMMA, PVC, ABS, SAN,Nylon6, 66, 12, PET, PBT, PC, PC-ABS Blends and POM.

**Unit – 3.2 - Injection molding**

3.2.1 Describe the injection molding process with its advantages and disadvantages.

3.2.2 Distinguish Different types of injection molding machines and describe the different parts of injection molding machines and their respective functions

3.2.3 Explain the screw design and screw nomenclature of injection molding screws.

3.2.4 Explain the different types of injection molds, their parts and functions and different clamping systems

3.2.5 Describe the processing variables such as shot weight, barrel residence time, clamping force etc.

3.2.6 Demonstrate the setting of processing parameters in injection molding machine and operation of injection molding machine

3.2.7 Analyse the processing problems and solutions in injection molding

**Unit – 3.3 – Extrusion**

3.3.1 Describe the plastic extrusion process

3.3.2 Distinguishes the different types of Extruders and describe the different parts of extruders and their respective functions.

3.3.3 Explain the screw design and different types of screws in extrusion

3.3.4 Describe the production of pipes, profiles, cables, and blown films.

3.3.5 Demonstrate the extrusion operation

3.3.6 Analyse the problems and solutions arising in extrusion process

**Unit – 3.4 - Blow molding and rotational molding**

3.4.1 Describe the different blow molding operations like extrusion blow molding, injection blow molding and stretch blow molding

3.4.2 Analyse the problems, causes and remedies in blow molding operation

3.4.3 Describe the rotational molding of plastics

3.4.4 Analyse the defects, causes and remedies in rotational molding

**Unit – 3.5 - Thermoforming and calendaring**

3.5.1 Explain the different thermoforming processes and their respective features.

3.5.2 Identify the different thermoforming materials and applications.

3.5.3 Explain the plastic calendaring process and distinguish between different types of calenders.

3.5.4 Describe the different gauge control methods in calendaring.

**Unit – 3.6 - Testing of plastics**

3.6.1 Identify the significance of testing, specifications and standards

3.6.2 List the typical tests conducted in the plastic industry

3.6.3 Determine the specific gravity, hardness, tensile, flexural, and impact properties of plastics

3.6.4 Describe the testing of MFI, Vicat Softening point, Heat distortion temperature and Environment stress crack resistance of plastics

## MODULE IV – FIBRE REINFORCED COMPOSITES

**Unit - 4.1 - Introduction to composites**

4.1.1 Explains composites, its basic features and constituents of composites, role of matrix, reinforcement and interphase

4.1.2 Classifies different composites based on matrix, structure, and type of reinforcements, orientation and applications

**Unit – 4.2 Reinforcement Fibres**

4.2.1 Explains the functions and properties of reinforcing fibres used in composites

4.2.2 Identifies the different types of fibres like roving, continuous filaments, chopped strand mats, woven fabric etc

4.2.3 Describes the properties and applications of different types of glass fibres, carbon fibre, Aramid fibre, Boron fibre, UHMWHDPE fibres, and different natural fibres used in composites and their applications

**Unit – 4.3 Matrix Materials and Additives**

4.3.1 Describes the properties and applications of epoxy resins, polyester resins, phenolic resins and vinyl ester resins used in composites

4.3.2 Describes the curing reaction, gelation, gel time, cure time and cure rate of different thermoset resins

4.3.3 Describes the functions of various additives used in composites

4.3.4 Explains the use of different core materials in composites

**Unit – 4.4 Manufacturing Methods**

4.4.1 Describes different open mould FRP manufacturing processes such as Hand lay-up, spray-up, and filament winding.

4.4.2 Explains the preparation FRP products using closed mould processes such as compression moulding, vacuum bag moulding, pressure bag moulding, autoclave moulding and injection moulding.

4.4.3 Describes the preparation of prepregs, SMC and DMC compounds for FRP processing.

4.4.4 Explains the Resin transfer moulding and vacuum assisted resin transfer moulding methods

4.4.5 Explains the continuous processes such as pultrusion and braiding.

4.4.6 Prepares FRP products using different manufacturing processes.

**Unit –4.5 Quality and safety in FRP processing**

4.5.1 Identifies and practices safe storage of FRP raw materials

4.5.2 Practices good housekeeping and follow work instructions

4.5.3 Observes health and safety practices during FRP processing.

4.5.4 Explains the different process control parameters in FRP processing.

4.5.5 Prepares and maintain simple moulds using plaster of paris

4.5.6 Does minor repairs of FRP products

**SCHEME OF WORK**

| UNIT | MONTH | UNIT NAME | PERIOD |
|---|---|---|---|
| 3.1 | JUNE | Introduction to plastic processing | 20 |
| 3.2 | JUNE | Injection Molding | 48 |
| 3.2 | JULY | Injection molding | 42 |
| 3.3 | JULY | Extrusion | 26 |
| 3.3 | AUGUST | Extrusion | 34 |
| 3.4 | AUGUST | Blow molding and rotational molding | 34 |
| 3.4 | SEPTEMBER | Blow molding and rotational molding | 26 |
| 3.5 | SEPTEMBER | Thermoforming and Calendaring | 42 |
| 3.5 | OCTOBER | Thermoforming and Calendaring | 18 |
| 3.6 | OCTOBER | Testing of plastics | 50 |
| 4.1 | NOVEMBER | Introduction to composites | 30 |
| 4.2 | NOVEMBER | Reinforcement Fibres | 38 |
| 4.2 | DECEMBER | Reinforcement Fibres | 2 |
| 4.3 | DECEMBER | Matrix Materials and additives | 60 |
| 4.4 | DECEMBER | Manufacturing Methods | 6 |
| 4.4 | JANUARY | Manufacturing Methods | 68 |
| 4.4 | FEBRUARY | Manufacturing Methods | 66 |
| 4.5 | FEBRUARY | Quality and Safety in FRP Processing | 2 |
| 4.6 | MARCH | Quality and Safety in FRP Processing | 68 |

## Module III

## PLASTIC PROCESSING

| Unit No. | Name of Units | Period |
|---|---|---|
| 1 | Introduction to plastic processing | 20 |
| 2 | Injection Molding | 90 |
| 3 | Extrusion | 60 |
| 4 | Blow molding and rotational molding | 60 |
| 5 | Thermoforming and Calendaring | 60 |
| 6 | Testing of plastics | 50 |
| | Total | 340 |

30% theory and 70% practical

## Module IV

## Fibre reinforced composites

| | | |
|---|---|---|
| 1 | Introduction to composites | 30 |
| 2 | Reinforcement fibres | 40 |
| 3 | Matrix materials and additives | 60 |
| 4 | Manufacturing methods | 140 |
| 5 | Quality and safety in FRP processing | 70 |
| | Total | 340 |

30% theory and 70% practical

## CLASSROOM ACTIVITIES

- Product presentation through PowerPoint
- Exhibitions
- Charts
- Video Presentations
- Diagrams
- Animated CDs
- Group Discussions
- Debate
- Seminar
- Prepare questionnaire
- Assignment
- Interview
- Project
- Demonstration
- Quiz
- Survey

## Practical activities

## Module – III, plastic processing

1) Work practice on different plastic processing machines
2) Production of plastic molded products
3) Field visit to plastic blown film extrusion unit
4) Field visit to rotational molding and pipe extrusion unit
5) Testing of physical properties of plastics
6) Determination of Melt Flow Index of plastics

**Module IV Fibre reinforced composites**

1) Identification of different raw materials used in composites
2) Demonstrate the hardening of resin matrix
3) Study of the curing reaction of polyester resins using different types dosages of catalysts
4) Work practice using hand layup technique
5) Production of FRP products using vacuum infusion
6) Field visit to FRP products manufacturing units
7) Preparation of molds and patterns for FRP processing
8) Determine the cost of FRP products

## Module III

# PLASTIC PROCESSING

### Overview

Plastic material came in to existence by virtue of their superior performance and cost effectiveness over other conventional materials. Over the years application of plastics have been widened with the advent of new generation polymers, blends, alloys and composites. Everyday newer application are being promoted in key sectors of Indian economy like automobiles, agriculture, aerospace, building and construction, infrastructure, telecommunication, IT, medical and biomedical engineering, packaging etc. This in turn necessitates the need for different type of processing methods and machinery to produce quality plastic product at affordable cost. In simple terms plastic processing is "Get the shape and set the shape". Plastic processing can be defined as the process of converting the plastic raw materials into semi-finished or finished products. Examples buckets, mugs, soap boxes, crates, tanks, pipes, shampoo bottles, carry bags, ropes, bumpers etc.

A sound judgment and experience is required for successful design and fabrication of good plastic product. Design of quality plastic product requires knowledge of advantages and limitation of plastics, familiarity with processing methods. Worldwide extrusion consumes 36 wt: % of all plastic, injection moulding consuming 32 wt: %. Consumption by other process like blow moulding is 10% and calendaring 8%, compression moulding 3%, others 3%. Thermoforming which is the 4th major process used consumes at least 30% of extruded sheet and films that goes in to packaging.

After completing the module he/she will be able to identify various moulding machines and their parts. He will be able to identify various processing techniques used in plastic industry and he/she acquires hands on experience in semi automatic, automatic plastic processing machineries. He/she will be able to work as plastic compounder, operator, assistant technician of various plastic processing machineries, quality controller in plastic industries.

## UNIT I

## INTRODUCTION TO PLASTIC PROCESSING

### About the unit

It is very difficult to realise how important plastics have become to our everyday lives. Plastics give us the possibility of manufacturing well-designed, beautiful products from the very many different types of plastics materials that are commonly available today. Thermoplastics are generally processed by injection moulding, blow moulding, extrusion, rotational moulding, thermoforming etc. Thermosetting plastics are processed by compression / transfer moulding and others. This unit aims to cover the basic plastic processing techniques and processing related properties of plastics.

### UNIT FRAME

| MODULE 3 | | | |
|---|---|---|---|
| **PLASTIC PROCESSING** | | | |
| **UNIT 3.1** | **INTRODUCTION TO PLASTIC PROCESSING** | | |
| **Ideas/ Concepts / Skills** | **Learning Outcomes** | **Suggested activities** | **Assessment** |
| Introduction to plastic processing, Different plastic processing techniques. – Injection Molding, Blow Molding, Compression molding, Extrusion, Rotational Molding, Thermo forming etc.<br>**Skills**<br>Observing,<br>Communicating, | The learner will be able to<br>Explain the basic plastic processing techniques such as injection molding, blow molding, extrusion processes | General discussion with PPT, video and Plastic Product samples<br>Chart | Participation in discussion<br>Chart |
| Effect of polymer properties on processing. Moisture absorption, Thermal stability.<br>**Skills**<br>Observing,<br>Communicating<br>Inferring | The learner will be able to<br>Analyze the influence of polymer properties on the processing of polymers | Group discussion | Participation in discussion |
| Important properties, applications and processing parameters of common plastics such as HDPE, LDPE, PP, PS, PMMA, PVC, ABS, SAN,Nylon6, 66, 12, PET, PBT, PC, and POM.<br>**Skills**<br>Observing,<br>Communicating,<br>Inferring | The learner will be able to<br>Describe the properties, applications and processing parameters of common plastics such as HDPE, LDPE, PP, PS, PMMA, PVC, ABS, SAN,Nylon6, 66, 12, PET, PBT, PC, PC-ABS Blends and POM. | Interactive lecture with PPT, video show | Participation in discussion |

## Additional Information

**POLY TETRAFLOUROETHYLENE (TEFLON)**

Poly tetraflouro ethylene is a synthetic flouro polymer that has a number of applications. PTFE is hydrophobic and has very low coefficient of friction and very high temperature resistance. PTFE is used as nonstick coating for cookware and also used as coatings to reduce friction and wear in many applications. From cookwares to space applications Teflon touches every one of us some way almost every day.

PTFE was accidently discovered by Roy J Plunkett in 1938 while he was working for DuPont. While doing research on some refrigerants Plunkett filled tetraflouroethylene in a pressure vessel and kept as such. Next day he found that the pressure inside the vessel has been dropped. While checking for any leakage he found that the weight of the vessel is unchanged. So he cut open the vessel and found that a waxy material is deposited on the inner surface of the vessel. Tetraflouroethylene is polymerized to form Polytetraflouroethylene under high pressure and iron catalyst.

## Assessment Activities

Quiz on the common plastics and their properties and applications
Oral Test on the different processing techniques for plastics
Group Discussion on processing related properties of plastics

## List of items in portfolio

Chart of various plastic processing techniques

Group discussion report on effect of polymer properties on plastic processing

Write up on the properties and applications of common plastics

# UNIT – 2
# INJECTION MOLDING

## About the unit

Injection molding is one of the most common methods of converting plastic raw material to a product. This process is used for thermo plastic material and other polymeric material which may successively melted, reshaped and cooled. Injection molded plastic components finds applications as components of almost every functional manufactured article in the modern world, from automotive products to food packaging to common house hold articles. This versatile process allows rapid production of high quality, simple or complex components on a fully automated basis. This unit covers the basic features of injection molding, different types of injection molding machines, clamping units and molds, operation cycle and troubleshooting guide.

**UNIT FRAME**

| **MODULE 3** | | | |
|---|---|---|---|
| **PLASTIC PROCESSING** | | | |
| **UNIT 3.2** | **INJECTION MOLDING** | | |
| **Ideas/ Concepts / Skills** | **Learning Outcomes** | **Suggested activities** | **Assessment** |
| Injection moulding process - advantages, disadvantages. Injection moulding machine - plunger type, screw type. Different parts of injection moulding machines and their respective functions. | The learner will be able to<br><br>Describe the injection molding process with its advantages and disadvantages.<br><br>Distinguish different injection molding machines, their parts and respective function | Interactive lecture using PPT, videos<br><br>Assignment – diagram of machine | Participation in discussion<br><br>Oral assessment<br><br>Assignment |
| Screw Design – feed, transition and metering zones, L/D ratio, compression ratio, helix angle, types of screws. | The learner will be able to<br><br>Explain the screw design and screw nomenclature of injection molding screws | Interactive lecture using PPT.<br><br>Assignment - Screw design and screw types | Participation in discussion<br><br>Assignment |
| Clamping Systems - Manual clamping, Toggle clamping, Hydraulic clamping, and Tie bar less clamping. Moulds - two plate moulds, three plate moulds. Parts of moulds - Runner - cold runner, hot runner, gate, ejection systems, cooling channels | The learner will be able to<br><br>Explain the different types of injection molds, their parts and functions and different clamping systems | General Discussion with PPT<br>Demonstration in Laboratory | Participation in discussion<br><br>Write ups |

| | | | |
|---|---|---|---|
| Process parameters - Shot weight, Barrel residence time, Clamping force, - melt and mould temperatures, screw speed, back pressure, injection pressure and holding pressure, injection speed, holding time, cooling time, mould open time. Moulding cycle. | The learner will be able to<br><br>Describe the processing variables such as shot weight, barrel residence time, clamping force etc.<br>Demonstrate the setting of processing parameters in injection molding machine and operation of injection molding machine | General discussion with PPT,<br><br>Case studies<br><br>Lab work | Participation in discussion,<br><br>Write ups<br><br>Oral Assessment<br><br>Lab records |
| Processing defects, causes, and remedies. | The learner will be able to<br><br>Analyze the processing problems and solutions during Injection molding | Analysis of defective product samples. | Chart |

## Assessment Activities

Assignment – diagram of different injection moulding machne

Assignment - Screw design and screw types

Chart – Processing defects causes and remedies

Class test

## List of item in portfolio

Assignment

Chart

Lab Record

# UNIT 3
# EXTRUSION

**About the unit**

The extruder is one of the most important machinery in the polymer processing industry. To extrude means to push or to force out. Material is extruded when it is pushed through an opening. When toothpaste is squeezed out of a tube, it is extruded. The part of the machine containing the opening through which the material is forced is referred to as the extruder die. As material passes through the die, the material acquires the shape of the die opening. The extruded product is referred to as the extrudate. Extrusion is used for producing continuous profiles and pipes. This unit deals with different types of extruders, their parts, functions and operation of extruders, manufacture of pipes, cables, packing films etc

**UNIT FRAME**

| **MODULE 3** | | | |
|---|---|---|---|
| **PLASTIC PROCESSING** | | | |
| **UNIT 3.3** | **EXTRUSION** | | |
| **Ideas/ Concepts / Skills** | **Learning Outcomes** | **Suggested activities** | **Assessment** |
| Plastic extrusion process. Classification of extruder, different parts and its function of screw extruder - feed hopper, extruder barrel and screw, feed, compression, metering zones, dies, screen pack, breaker plate, heating and cooling elements and drive system. Extrusion dies - solid cross section and hollow cross section dies. | The learner will be able to<br>Describe the extrusion process<br>Identify the parts and their respective functions<br>Distinguish the different types of extruders and describe the different parts of extruders and their respective function | Interactive lecture, Charts, models, field visit | charts,<br>Write ups<br>field visit report |
| Screw nomenclature, types of screws - polyolefin, PVC and Nylon screws, | The learner will be able to<br>Explain the screw design and different types of screws in extrusion | Interactive lecture with PPT | Participation in lecture<br>Write ups |
| Sheet extrusion, profile extrusion, pipe extrusion, blown film extrusion, extrusion of cable. | The learner will be able to<br>Describes the production of Pipes, profiles, cables and blown films<br>Demonstrates the extrusion operation. | Interactive lecture, field visit, work practice on extruder | Charts,<br>Field visit report |

| | | | |
|---|---|---|---|
| Processing defects and their remedies<br>Extrudate swell, melt fracture. | The learner will be able to<br><br>Analyse the problems and solutions arising while extrusion | Analysis of defective product samples. | Participation in discussion, sample collection |

## Additional information

### Compounding of PVC for pipes

Most plastics can be easily extruded to produce long products. But PVC needs to be compounded with many additives to get a good quality trouble free extrusion. Various ingredients used in PVC compounding and their functions can be discussed for additional information

### Assessment Activities

Field visit to a pipe extrusion unit
Case study
Chart preparation
Oral assessment
Unit test.

### List of items in Portfolio

Field visit report
Write up
Chart
Lab records

# UNIT 4

# BLOW MOLDING & ROTATIONAL MOLDING

## OVERVIEW

Blow molding is a manufacturing process in which air pressure inflates heated plastic in a mold cavity. It is used for the production of hollow plastic parts with thin walls, such as beverage bottles, cosmetic containers and pharmaceutical packaging. Another method used for the manufacture of hollow articles such as water tanks rotational molding. This unit details the different blow molding and rotational molding operations used in plastic industry.

**UNIT FRAME**

| **MODULE 3** | | | |
|---|---|---|---|
| **PLASTIC PROCESSING** | | | |
| **UNIT 3.4** | **BLOW MOLDING AND ROTATIONAL MOLDING** | | |
| **Ideas/ Concepts / Skills** | **Learning Outcomes** | **Suggested activities** | **Assessment** |
| Blow molding, Different types of blow molding - Extrusion blow molding, injection blow molding, stretch blow molding. | The learner will be able to<br>Describe the different blow molding operations like extrusion blow molding, injection blow molding and stretch blow molding | Interactive lecture with PPT,<br>Video show<br>Field visit | Participation in discussion<br>Field visit report |
| Problems and trouble shooting in blow molding. | The learner will be able to<br>Analyse the problems, causes and remedies in blow molding operation | Interactive lecture with PPT<br>Field visit,<br>Analysis of defective samples | Participation in discussion<br>Write up |
| Rotational molding – Advantages, disadvantages, Rotational molding vs blow molding, | The learner will be able to<br>Describe the rotational molding of plastics | Interactive lecture with PPT<br>Field visit | Participation in discussion<br>Field visit report |
| Faults and remedies in rotational molding. | The learner will be able to<br>Analyse the defects, causes and remedies in rotational molding | Analysis of defective product samples. | Participation in discussion<br>Write up |

**Additional information**

Rotational moulding is now emerging as a stress free technique to produce hollow plastic products. Data collection and seminar about new developments and products made by rotational moulding.

**Assessment Activities**

Field visit
Case study
Chart preparation

**List of items in portfolio**

Write up
Field visit report

## UNIT 5
## THERMOFORMING & CALENDARING

**Over view of the unit**

This unit deals with two major processing processes- thermoforming, used for manufacturing a range of products from cups to boat hulls and rotational molding widely used to produce hollow articles like tanks.

**UNIT FRAME**

| **MODULE 3** | | | |
|---|---|---|---|
| **PLASTIC PROCESSING** | | | |
| **UNIT 3.5** | **THERMOFORMING & CALENDERING** | | |
| **Ideas/ Concepts / Skills** | **Learning Outcomes** | **Suggested activities** | **Assessment** |
| Thermoforming, Different forming processes— vacuum forming, pressure forming, plug assisted forming, drape forming, matched mold forming. Materials, applications, advantages, disadvantages of thermoforming | The learner will be able to<br><br>Explain the different forming processes and their respective features<br><br>Identify different thermoforming materials and their applications | Interactive lecture,<br><br>visual media ,<br><br>Seminar | Participation in discussion<br><br>Seminar report |
| Calendaring of plastics Different types of calenders – I type, L type, and Z type | The learner will be able to<br><br>Explain the plastic calendaring process and distinguish between different types of calenders. | Interactive lecture with PPT, Assignment | Participation in discussion<br><br>Assignment |
| Gauge control in calendaring - roll bending, roll crossing, and roll crowning. | The learner will be able to<br><br>Describe the different gauge control methods in calendaring. | Interactive lecture with PPT | Participation in discussion<br>Oral test |

**Assessment Activities**

Seminar
Participation in discussion
Oral Evaluation

**List of items in Portfolio**

Chart
Seminar report

## UNIT - 6

## TESTING OF PLASTICS

Plastic and plastic products are becoming more and more customer oriented and hence have to be tested for ensuring the quality and performance requirements. This unit deals with the mechanical, thermal and environmental testing of plastic raw materials and plastic products.

**UNIT FRAME**

| **MODULE 3** | | | |
|---|---|---|---|
| **PLASTIC PROCESSING** | | | |
| **UNIT 3.6** | **TESTING OF PLASTICS** | | |
| **Ideas/ Concepts / Skills** | **Learning Outcomes** | **Suggested activities** | **Assessment** |
| **Testing of plastics**<br>Need for testing<br>Specification and standards | The learner will be able to<br><br>Identify the significance of testing, specifications and standards | Interactive lecture, | Participation in discussion |
| Physical Properties - specific gravity of plastics<br>Tensile properties,<br>Flexural properties,<br>Hardness<br>Impact testing –Charpy and Izod impact test,<br>Melt flow index (MFI)<br>Thermal tests- HDT, Vicat softening point,<br>Environmental Stress Crack Resistance | The learner will be able to<br><br>List the typical tests conducted in the plastic industry<br><br>Determine the specific gravity, hardness, tensile, flexural, and impact properties of plastics<br><br>Describe the testing of MFI, Vicat Softening point, Heat distortion temperature and Environment stress crack resistance of plastics | Lab work<br><br>Interactive lecture,<br><br>Multimedia presentation<br><br>Field visit | Practical evaluation<br><br>Participation in discussion<br><br>Field visit report |

**Assessment Activities**

Practical evaluation

Oral Evaluation

Class test

Field visit report

**List of items in Portfolio**

Field visit report

Lab record

## Extended Activities

Seminar on the processing of thermoset plastics such as PF, MF and UF resins

Poster preparation of multiple extrusion

Poster preparation of multi component injection moulding

Poster presentation on applications of PVC

# MODULE IV

# Fibre Reinforced Composites

## OVERVIEW

Fibre-reinforced plastic (FRP), is a composite material made of a polymer matrix reinforced with fibres. The fibres are usually glass, carbon, or aramid. Other fibres such as paper, wood or asbestos etc were rarely used. The polymer used is usually an epoxy, vinyl ester or polyester thermosetting plastic. Combining fibres with resin matrix results in composites that are strong, lightweight, corrosion-resistant and dimensionally stable. They also provide good design flexibility and require lower tooling costs. Because of these advantages, composites are being used in a growing number of industries, such as aerospace, automobile, civil infrastructure, wind energy, marine and sports. Their high strength-to-weight ratio and design flexibility make them ideal in structural components. High-strength lightweight premium composite materials such as carbon fibre - epoxies are being used for aerospace applications and in high performance sporting goods. Composite's superior electrical insulating properties also make them ideal for appliances, tools and machinery. Tanks and pipes constructed with corrosion-resistant composites offer extended service life over those made with metals.

One of the advantages of composites is that, their components – fibre and resin matrix, complement each other. While thin fibres are quite strong, they are also susceptible to damage. Plastics are relatively weak, but are versatile and tough. Combining these two components together, however, results in a material that is more useful than either is separately. With the right fibre, resin and manufacturing process, designers today can tailor composites to meet final product requirements that could not be met by using other materials.

This module is divided into six units. The first unit covers the fundamentals of Fibre reinforced composites, basic features and applications. Then different reinforcements, matrix materials and other additives used in Fibre reinforced composites dealt in detail in the units 2, 3 and 4 respectively. Fifth unit is dedicated to the various manufacturing processes used for making FRP products. The sixth unit deals with the design of FRP products, materials selection, mold or pattern making, testing and repair of composites.

# UNIT – I
# INTRODUCTION TO COMPOSITES

**Overview**

This unit is an introduction to composite materials. It deals with the basic features, components, properties and applications of fibre reinforced composites. Classification of different composites, advantages, disadvantages and comparison of composite materials with conventional materials are also covered.

**UNIT FRAME**

| **MODULE 4** | | | |
|---|---|---|---|
| **FIBRE REINFORCED PLASTICS** | | | |
| **UNIT 4.1** | **INTRODUCTION TO COMPOSITES** | | |
| **Ideas/ Concepts / Skills** | **Learning Outcomes** | **Suggested activities** | **Assessment** |
| Definition of composites,<br>Basic features of composites,<br>Constituents of composites – Matrix, reinforcement and interphase.<br>Advantages, disadvantages and applications of composites.<br>**Skills**<br>Observing,<br>Communicating, | The learner will be able to<br><br>Explain Composites, basic features and constituents of composites, role of matrix, reinforcement and interphase | General discussion with PPT, video show and FRP Product samples<br><br>Assignment – Applications of composites | Participation in discussion<br><br>Assignment |
| Classification of composites – based on matrix, based on reinforcement, orientation etc.<br>**Skills**<br>Observing,<br>Communicating<br>Inferring | The learner will be able to<br>Classify different composites based on matrix, structure, type of reinforcements, orientation and applications | General discussion with PPT,<br><br>Chart | Participation in discussion<br><br>Chart |

**Assessment Activities**

1) Assignment of the application of composites.
2) Chart – Classification of composites

**List of items in portfolio**

1) Write ups
2) Assignment
3) Chart
4) Practical record

# UNIT – II
# REINFORCEMENT FIBRES

**Overview**

Reinforcing fibres are a key component of polymer matrix composites. They impart high strength and stiffness to the matrix materials. This unit deals with different kinds of reinforcement fibres used for making Fibre Reinforced Composites. Different fibres such as Glass fibre, Carbon fibre, Aramid fibres etc and the different forms in which they are used in composites are also discussed. The terminologies used in fibre science are also provided understand the fibre characteristics.

**UNIT FRAME**

| **MODULE 4** | | | |
|---|---|---|---|
| **FIBRE REINFORCED PLASTICS** | | | |
| **UNIT 4.2** | **REINFORCEMENT FIBRES** | | |
| **Ideas/ Concepts / Skills** | **Learning Outcomes** | **Suggested activities** | **Assessment** |
| Functions of reinforcement, requirements of reinforcement fibres, terminology used in fibre science<br>**Skills**<br>Observing,<br>Communicating, | The learner will be able to<br><br>Explain the functions and properties of reinforcing fibres used in composites | General discussion with PPT, fabric samples | Participation in discussion<br><br>Write ups |
| Forms of reinforcement – Chopped strand mat (CSM), continuous filament mat, chopped stands, veil, woven roving/fabric. | The learner will be able to<br><br>Identify the different types of fibres like roving, continuous filaments, chopped strand mats, woven fabric etc<br>. | Group discussion with fabric samples and product hand outs | Participation in discussion<br><br>Report |
| Glass fibres – E Glass, S Glass, C-Glass, Carbon fibre, Aramid fibre, Boron fibre, UHMWHDPE, Natural fibres – Flax, Hemp, Jute, Sisal<br>**Skills**<br>Observing,<br>Communicating<br>Inferring | The learner will be able to<br><br>Describe the properties and applications of glass fibres, carbon fibre, Aramid fibre, Boron fibre, UHMWPE fibres, and different natural fibres used in composites and their applications | General discussion with PPT, video show<br><br>Assignment – comparison of different fibres | Participation in discussion<br><br>Assignment |

**Assessment Activities**

1) Assignment – Comparison of different fibres
2) Group discussion – Different forms of reinforcement.

**List of items in Portfolio**

1) Write ups
2) Assignment
3) Practical record

## UNIT – 3

## MATRIX MATERIALS AND ADDITIVES

In composites, the resin matrix acts as a binding agent which holds the fibres together and assists the fibres in carrying the loads. Polyester and epoxy resins are the most widely used resins in the FRP industry. Apart from this other thermoset resins such as phenolic resins, polyurethanes and certain thermoplastics like Poly ether ether ketone, nylon, poly ether imide etc are also used as matrix materials. Thermoplastic composites are used in small quantities and hence are not included in this unit. Thermoset resins require curing agents, catalysts, filler, pigments etc, to develop full functional properties. In addition to this core materials, which are widely used to enhance the stiffness and reduce weight and saves materials are also covered in this unit.

### UNIT FRAME

| **MODULE 4** | | | |
|---|---|---|---|
| **FIBRE REINFORCED PLASTICS** | | | |
| **UNIT 4.3** | **Matrix materials and additives** | | |
| **Ideas/ Concepts / Skills** | **Learning Outcomes** | **Suggested activities** | **Assessment** |
| Functions of matrix, Thermosets and thermoplastics, Polyester resins, Epoxy resins, Phenolic resins, Vinyl ester resins.<br>**Skills**<br>Observing,<br>Communicating, | The learner will be able to<br>Describe the properties and applications of polyester resins, vinyl ester resins, epoxy, and phenolic resin | General discussion with PPT,<br>Demonstration | Participation in discussion<br>Write ups |
| Curing reactions, gelation and gel time, cure time, reaction rates. Catalyst or initiators, Accelerators – cobalt naphthenate, Inhibitors- Tertiary Butyl Catechol, Curing agents – Amines, anhydrides, Fillers, Pigments and dies, Lubricants, Light stabilizers, Anti static agents, heat stabilizers, Colorants Release agents and sealing compounds, Coupling agents. Core materials. | The learner will be able to<br>Describe the curing reaction, gelation, gel time, cure time and cure rate of different thermoset resins<br>Describe the functions of various additives used in composites<br>Explain the use of different core materials in composites | Interactive lecture with PPT<br>Demonstration – resin curing.<br>Seminar – core materials | Participation in discussion<br>Write ups<br>Seminar Report |

**Assessment Activities**

1) Seminar on core materials
2) Group discussion – Different thermoset resins and applications

**List of items in Portfolio**

1) Write ups
2) Practical record
3) Seminar report

# Unit – 4
# Manufacturing methods

**Introduction**

Reinforced plastics composites are a combination of resin matrix, fibres and fillers, which when cured produces a solid structure. There are plenty of methods to produce a composite structure. Each method has its own merits and limitations. Selection of particular manufacturing process is based on the type of matrix and fibres, temperature to form and cure the matrix, the geometry of the end product and cost effectiveness. This unit covers the various manufacturing methods used in the FRP industry.

**UNIT FRAME**

| **MODULE 4** | | | |
|---|---|---|---|
| **FIBRE REINFORCED PLASTICS** | | | |
| **UNIT 4.5** | **Manufacturing Methods** | | |
| **Ideas/ Concepts / Skills** | **Learning Outcomes** | **Suggested activities** | **Assessment** |
| Manufacturing processes - Open mould processes - Hand layup, Spray up, and filament winding. Closed mould processes – Compression moulding, Vacuum bag molding, Pressure bag molding, autoclave molding, and injection moulding.<br><br>**<u>Skills</u>**<br>Observing,<br>Communicating, | The learner will be able to<br><br>Describe different open mould FRP manufacturing processes such as hand lay up, spray lay up and filament winding.<br><br>Explain the preparation of FRP products using closed mould processes such as compression moulding, vacuum bag moulding, pressure bag moulding, autoclave moulding and injection moulding. | General discussion with PPT, video show<br><br>Demonstration<br><br>Lab work<br><br>Field visit | Participation in discussion<br><br>Write ups<br><br>Practical record |
| Preparation of fibre reinforcements and resins, Molding compounds - Dough molding compound (DMC) and Sheet molding Compound (SMC), Prepregs. | The learner will be able to<br><br>Describe the preparation of SMC, DMC and Prepregs | General discussion with PPT, video show<br><br>Demonstration | Participation in discussion<br><br>Write ups |
| Resin Transfer Moulding and Vacuum assisted resin transfer moulding.<br><br>Continuous processes – pultrusion and braiding | The learner will be able to<br>Explain the resin transfer moulding and vacuum assisted resin transfer moulding methods | General discussion with PPT,<br><br>Field visit | Participation in discussion<br><br>Field visit |

| | | | |
|---|---|---|---|
| | Explain the continuous processes such as pultrusion and braiding.<br><br>Prepare FRP products using different manufacturing processes. | Lab work | report<br>Lab record |

**Assessment Activities**

1) Field visit report on FRP manufacturing methods
2) Group discussion – Faults causes and remedies in FRP processing.

**Portfolio**

1) Write ups
2) Practical record
3) Field visit report

## UNIT – 5

## QUALITY AND SAFETY IN FRP PROCESSING

The essential difference between FRP composites and almost all other structural materials is that, whilst the chemical composition and properties of other materials e.g. steel or aluminium, are mainly determined by the manufacturer, with reinforced plastics the fabricator determines these properties himself i.e. he makes his own material. Quality control is therefore extremely important if high quality moldings are to be produced consistently, economically and safely. This section deals with aspects of quality control from the storage of materials through the various stages of molding production to the delivery of quality molded parts.

**UNIT FRAME**

| **MODULE 4** | | | |
|---|---|---|---|
| **FIBRE REINFORCED PLASTICS** | | | |
| **UNIT 4.5** | **Manufacturing Methods** | | |
| **Ideas/ Concepts / Skills** | **Learning Outcomes** | **Suggested activities** | **Assessment** |
| Storage of raw materials, Workshop conditions – Reinforcement preparation area, Compounding and mixing area, Mold preparation and molding area, Finishing area.<br>**Skills**<br>Observing,<br>Communicating, | The learner will be able to<br><br>Identify and practice safe storage of FRP raw materials<br><br>Practice good housekeeping and follow work instructions<br><br>Observe health and safety practices during FRP processing | General discussion<br><br>Demonstration<br><br>Assignment | Participation in discussion<br><br>Write ups<br><br>Assignment |
| Process care – Curing reaction, gel time, hardening time, maturing time, Hot cure, cold cure, resin to glass ratio, degree of cure.<br><br>Preparation of moulds<br><br>Repair of composites – repair of gel coat layer, filling dents and cracks | The learner will be able to<br><br>Explain the different process control parameters in FRP processing.<br><br>Prepare and maintain simple molds using plaster of paris, FRP<br><br>Do minor repairs of FRP products | General discussion<br><br>Lab work | Participation in discussion<br><br>Lab record |

**Assessment Activities**

1) Laboratory work
2) Assignment of the health and safety practices in FRP industry.

**List of items in Portfolio**

1) Assignment
2) Practical record
3) Write up

## Extended Activities

1) Collection of data regarding the applications of composites in aerospace applications
2) Prepare a project report for starting a new biogas plant production unit
3) Work out the cost of FRP products made in the laboratory
4) Seminar on the production of wind mills using FRP
5) Seminar on the production of speed boats using vacuum infusion technique

## ON THE JOB TRAINING

On the job training which is an integral part of vocational education that takes place in real job situations under the supervision of an expert in plant supervisor aiming at the development of proficiency and self confidence The OJT program is of 4 weeks duration. It can be done in two spells of 2 week each during the second module, and fourth module.For the OJT of Polymer technology course Rubber, Plastics, and Fibre reinforced plastic industries can be chosen.

A list of industries is given below

**Rubber**

1. Rubber Research Institute of India Puthuppally
2. MIDAS Retreads
3. Paragon
4. MRF
5. Rubco
6. CFSC Changanacherry
7. Vajra Rubber
8. Rubber park, Irapuram

**Plastics**

9. Centre for Bio polymer science and Technology, Kochi
10. Family plastics
11. Kavery plastics
12. Plastoplast
13. Nediyara extrusions
14. Shakthiman super
15. Hycount
16. Megha water tanks etc.

**Fibre reinforced plastics**

17. Matha marines
18. Wonderla
19. Festel tanks

## References:


1. Fundamentals of Plastics processing (Vol.1) Injection and blow moulding by Sanjay K Nayak.
2. Plastics Engineering Handbook By Fradoes J
3. Injection Moulding by A.S.Athalye
4. Injection Moulding Machines by F.Johannaber
5. Plastics Processing Handbook by J.A.Brydson
6. Plastics Processing Data Handbook by Donald V.Rosato & Dominick V.Rosato
7. Extrusion of Plastics - Fisher
8. Plastic Materials and Processing - A. Brent Strong
9. Lee, N. C., Plastic blow Moulding Handbook, Van Nostrand Reinhold.
10. Engineered Materials Handbook, ASM International Handbook committee, USA.
11. Polymer Processing by Baird
12. Advanced composite materials by Lalit Gupta
13. FRP Technology by Weatherhead
14. Fiber Reinforced composites by PK Mallick
15. Engineering composite materials by Bryan Harris.