

Trade of Toolmaking	
Module 5:	Press Tools, Jigs & Fixtures, Mouldmaking
Unit 11:	Polymer Materials
	Phase 2

Published by



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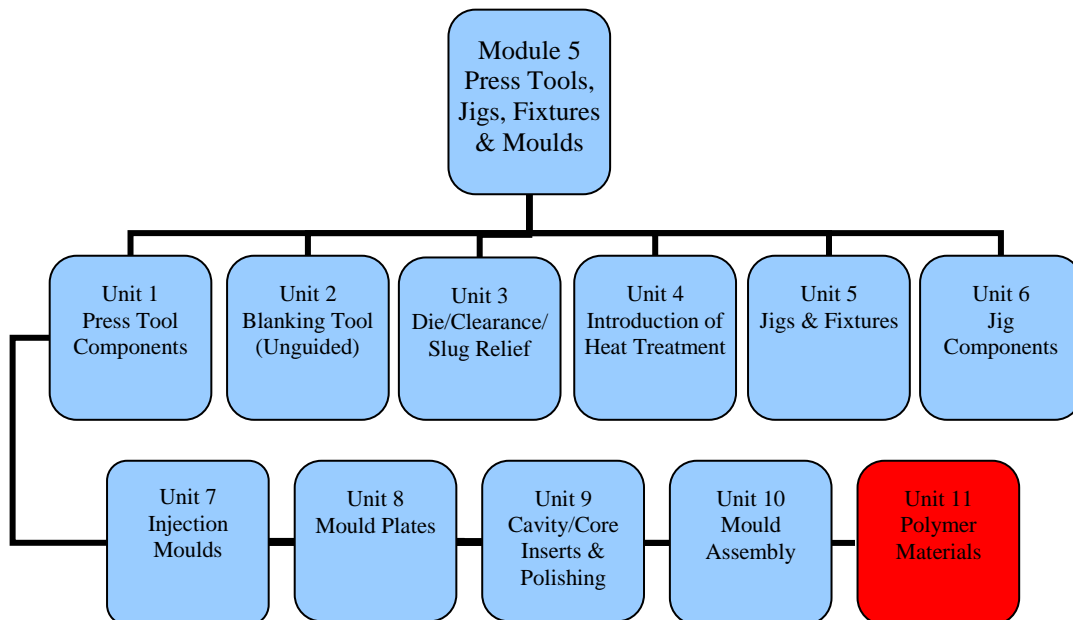
Unit Objective

On completion of this unit you will be able to define the term polymer and describe the different types of plastics and their properties.

Introduction

Module five of this course covers Press Tools, Jigs & Fixtures, Mouldmaking. This is the eleventh unit in module five and describes the structures of polymers. Plastics are compounds of carbon with the addition of a small group of other elements. Plastics are made up of long chains of molecules called monomers, which join together to form larger molecules.

There are many different types of plastics, where some are soft and flexible, others hard and brittle and more strong and tough. Some plastics have excellent electrical and thermal properties and others have good resistance to water, solvents, chemicals and acids. Plastics are divided into two classes, thermoplastics and thermosetting plastics.



By the end of this unit you will be able to:

- Define the term 'Polymer' and describe the structure of polymers.
- Describe the difference between thermoplastic and thermoset plastic.
- List and describe the properties of common polymer materials.

1.0 Defining The Term ‘Polymer’ And Describe The Structure Of Polymers

Key Learning Points

Definition of term ‘Polymer’. Definition of term ‘Plastic’. Polymer chains and polymerisation. Advantages of polymer materials.

1.1 Definition Of Term ‘Plastic’

Plastic the general term for a wide range of synthetic or semi-synthetic products.

1.2 Definition Of Term ‘Polymer’.

A Polymer is a large molecule, which are made by joining many smaller molecules together.

1.3 Polymer Chains And Polymerisation

The small molecules are called monomers and are derived from natural gas and crude oil and form long chain molecules. This process is called polymerisation. Plastics are compounds of carbon with the addition of a small group of other elements such as oxygen, hydrogen, nitrogen, chlorine and fluorine.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 14, *Plastics*, p. 234.
ISBN-13: 9780750660730

1.4 Advantages Of Polymer Materials

The advantage of using plastics is that they can be easily moulded and formed into shape. Plastic can also be machined on conventional machines such as mills and lathes.

2.0 Difference Between Thermoplastic And Thermoset Plastics

Key Learning Points

Distinction between thermoplastic and thermoset polymer. Typical uses and applications of thermoplastic polymers: polyethylene, polypropylene, polyvinyl chloride (PVC), polystyrene, nylon, PTFE, polycarbonate. Typical uses and applications of thermosetting polymers: phenolic resins, polyurethane, urea formaldehyde, epoxies and polyesters.

2.1 Distinction Between Thermoplastic And Thermoset Polymer

Thermoplastics: These plastics become soft and pliable when heated and return to their original state when cool.

Thermosetting plastic: When heated these plastics undergo a chemical change, which cannot be reversed.

2.2 Typical Uses And Applications Of Thermoplastic Polymers

Thermoplastics – These plastics become soft and pliable when heated and returns to their hardened state when cool. The heating and cooling process can be carried out many times without causing the plastic to deteriorate. These plastics include:

- *Polyamide* (nylon) used for gears, bearings, hinges, food packaging
- *PMMA* (Perspex) used for sign, displays, windows, light fittings
- *PTFE* used electrical insulation, bearings, has a high resistance to chemicals
- *Polyvinyl chloride* (PVC) used for pipes, fittings, wire insulation, bottles, floor coverings
- *Polypropylene* used for, car interior panels, crates, has a high resistant to chemicals
- *Polycarbonate* used for pipes, lenses, DVD's, iPod player cases, riot shields, visors
- *Polyethylene* (or polythene) is used for bags, boxes, pipe, sheet
- *Polystyrene* used for thin walled containers, vending cups, fridge liners, photographic film

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 14, *Plastics; Thermosetting plastics*, p. 236.
ISBN-13: 9780750660730

2.3 Typical Uses And Applications Of Thermosetting Polymers

Thermoset plastics – When these plastics are heated they go through chemical change, which cross link the long chains and therefore cannot be reversed. These types of plastics have good heat and wear resistance properties and are used for industrial and domestic use for products such as heat resistant surfaces and table wear. These plastics include *Phenolic Resins* used for electrical insulators, saucepan handles; *Polyurethane* used as foam behind fridge panels, insulation panels, mouldings for door frames; *Urea Formaldehyde* used for electrical fittings, plugs; *Epoxy* used in paints, adhesives, electrical insulators, repairing boats and *Polyesters* used for yachts and car body parts.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 14, *Plastics; Thermosetting plastics*, p. 234.
ISBN-13: 9780750660730

3.0 Describing The Properties Of Common Polymer Materials

Key Learning Points

Properties of thermoplastic materials: effect of heat. Properties of thermosetting polymers: effect of heat. Use of manufacturers' data to select appropriate polymer materials for specific applications.

3.1 Properties Of Thermoplastic Materials: Effect Of Heat

Thermoplastics – These plastics become soft and pliable when heated and returns to their hardened state when cool. The heating and cooling process can be carried out many times without causing the plastic to deteriorate.

The properties of these materials are as follows:

- *Polyamide* (nylon) very durable and hard wearing, high elongation, resistant to mildew insects and chemicals
- *PMMA* (Perspex) transparent, easily machined, can be used outdoors
- *PTFE* highly resistance to chemicals, heat and has a low coefficient of friction, excellent electrical resistance
- *Polyvinyl chloride* (PVC) the second most widely used plastic, has a wide range of hardness and flexibility, good strength, durable, electrical insulator and resistant to water and chemicals
- *Polypropylene* is a light plastic, but tough and rigid, highly resistant to chemicals
- *Polycarbonate* is temperature resistance, impact resistance and can be easily worked
- *Polyethylene* (or polythene) is the most highly used plastic world wide, highly resistance to chemicals, oil and water
- *Polystyrene* resistance to oil and water

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 14, *Plastics*, p. 234.
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3.2 Properties Of Thermosetting Polymers: Effect Of Heat

Thermoset plastics – When these plastics are heated they go through chemical change, which cross link the long chains and therefore cannot be reversed.

The properties of these materials are as follows:

- *Phenolic Resins* are very rigid, good electrical insulation, good resistance to water solvents and acids, low thermal conductivity
- *Polyurethane* have a wide range of stiffness and hardness, good insulation properties
- *Urea Formaldehyde* good resistance to oil, grease and solvents, good heat resistance, good electrical insulator, hard and rigid
- *Epoxy* high strength to weight ratio, good electrical insulation
- *Polyesters* low toxicity levels, good mechanical and chemical properties

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 14, *Plastics*, p. 234.
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3.3 Use Of Manufacturers' Data To Select Appropriate Polymer Materials For Specific Applications

The manufacturers' data should be used to select appropriate polymer materials for specific applications. This will give a breakdown of the chemical makeup of the polymer. It will also provide the melting point. It will list properties such as mechanical strength, its resistance to chemicals, solvents, oil and water. Electrical insulation properties and electrical resistance.

Summary

Defining the term ‘Polymer’ and describe the structure of polymers: Plastic the general term for a wide range of synthetic or semi-synthetic products. A Polymer is a large molecule, which are made by joining many smaller molecules together. The small molecules are called monomers and are derived from natural gas and crude oil and form long chain molecules. This process is called polymerisation. Plastics are compounds of carbon with the addition of a small group of other elements such as oxygen, hydrogen, nitrogen, chlorine and fluorine.

The advantage of using plastics is that they can be easily moulded and formed into shape. Plastic can also be machined on conventional machines such as mills and lathes.

Difference between thermoplastic and thermoset plastics: Plastics are divided into two classes, thermoplastics and thermosetting plastics.

Thermoplastics – These plastics become soft and pliable when heated and returns to their hardened state when cool. The heating and cooling process can be carried out many times without causing the plastic to deteriorate. These plastics include *Polyamide* (nylon), *PMMA* (Perspex), *PTFE*, *Polyvinyl chloride* (PVC), *Polypropylene*, *Polycarbonate*, *Polyethylene* (or polythene) and *Polystyrene*.

Thermoset plastics – When these plastics are heated they go through chemical change, which cross link the long chains and therefore cannot be reversed. These types of plastics have good heat and wear resistance properties and are used for industrial and domestic use for products such as heat resistant surfaces and table wear. These plastics include *Phenolic Resins*, *Polyurethane*, *Urea Formaldehyde*, *Epoxy* and *Polyesters*.

Describing the properties of common polymer materials: *Thermoplastics* – The properties of these materials are as follows: *Polyamide* (nylon) very durable and hard wearing, high elongation, resistant to mildew insects and chemicals; *PMMA* (Perspex) transparent, easily machined, can be used outdoors; *PTFE* highly resistance to chemicals, heat and has a low coefficient of friction, excellent electrical resistance; *Polyvinyl chloride* (PVC) the second most widely used plastic, has a wide range of hardness and flexibility, good strength, durable, electrical insulator and resistant to water and chemicals.

Thermoset plastics - The properties of these materials are as follows: *Phenolic Resins* are very rigid, good electrical insulation, good resistance to water solvents and acids, low thermal conductivity; *Polyurethane* have a wide range of stiffness and hardness, good insulation properties; *Urea Formaldehyde* good resistance to oil, grease and solvents, good heat resistance, good electrical insulator, hard and rigid; *Epoxy* high strength to weight ratio, good electrical insulation and *Polyesters* low toxicity levels, good mechanical and chemical properties.

Suggested Exercises

1. Define the term 'Polymer'.
2. What are the advantages of using plastics?
3. List four common thermoplastics and their uses.
4. List four common thermoset plastics and their uses.

Questions

1. What is the difference between 'Polymer' and 'Plastic'.
2. Explain briefly the process of polymerisation.
3. What are the advantages of polymer materials?
4. What are the chemical names for the following thermoplastics:
(i) Nylon,
(ii) Perspex
and (iii) PVC?
5. What happened when thermosetting plastics are heated?

Answers

1. (i) Plastic the general term for a wide range of synthetic or semi-synthetic products, (ii) A Polymer is a large molecule, which is made by joining many smaller molecules together.
2. Long chain molecules are formed from small molecules, which are called monomers. These molecules are derived from natural gas and crude oil.
3. They can be easily moulded and formed into shape. Some plastic can also be machined on conventional machines such as mills and lathes.
4. The chemical names are as follows: (i) Polyamide, (ii) Polymethyl methacrylate (PMMA) and (iii) Polyvinyl chloride.
5. When these plastics are heated they go through chemical change, which cross link the long chains and therefore cannot be reversed.

Recommended Additional Resources

Reference Books

Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology.

ISBN-13: 9780750660730

Timings, R.L. 1998, *Manufacturing technology*, vol. 1, 3rd edn, Pearson Education Limited.

ISBN-13: 9780582356931