Trade of Toolmaking	
Module 5:	Press Tools, Jigs & Fixtures, Mouldmaking
Unit 7:	Injection Moulds
	Phase 2

Published by

SOLAS
An tSeirbhís Oideachais Leanúnaigh agus Scileanna
Further Education and Training Authority

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Document Release History

Date	Version	Comments
25/09/2014	2.0	SOLAS transfer

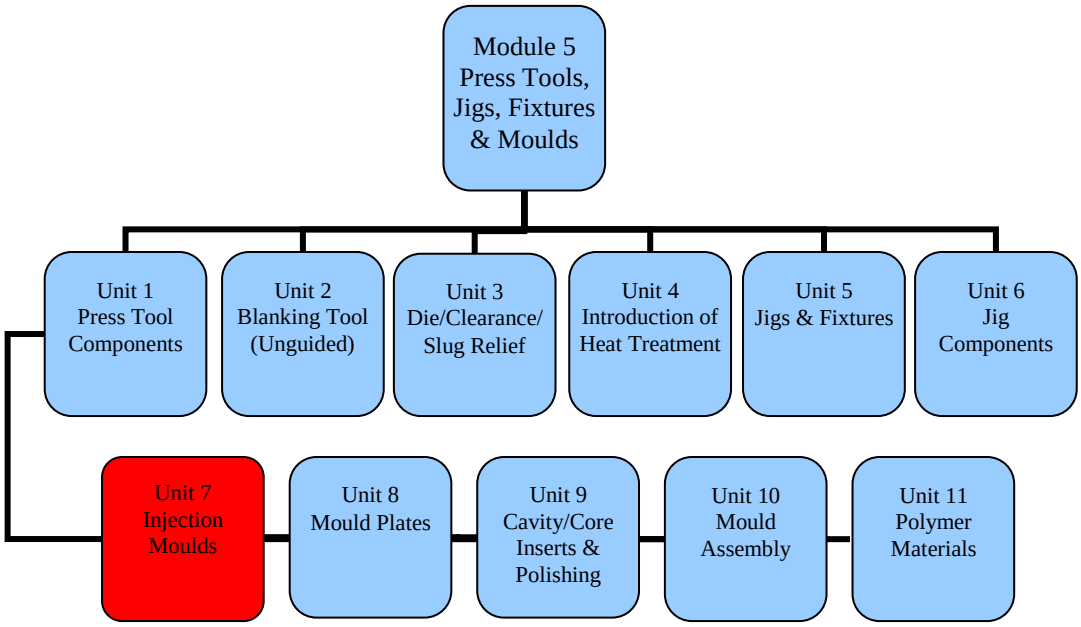
Unit Objective

On completion of this unit you will be able to describe the different types of plastics, identify the various parts of the injection mould and describe the mould cycle to produce a polymer component.

Introduction

Module five of this course covers Press Tools, Jigs & Fixtures, Mouldmaking. This is the seventh unit in module five and explains how plastic is shaped by the application of heat and pressure. This can be done in a compression mould, transfer mould or an injection mould. The type of mould that will be explained in this unit is the injection mould. Many types of plastics can be produced in this type of mould, which can be done at very high production rates and to a high degree of accuracy. The high cost of manufacturing these moulds means that they are more suited to high volume products.

The injection mould is used throughout the manufacturing industry to produce all types of products. The injection mould is set up in an injection moulding machine, which is used to inject the heated plastic into the mould under pressure. When the component has solidified the mould opens and the part is ejected.



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

- List and describe the variety of parts an injection mould can produce.
- Describe the principle difference between thermoplastic and thermoset plastic.
- Describe the mould cycle in a moulding machine to produce a polymer component.
- Identify and list the parts of an injection mould.
- State the function of the various parts that make up a single cavity cold runner, non slider mould.
- Review and select standard parts in catalogues.
- Apply machining techniques to achieve surface finish required.

1.0 The Variety Of Parts That Can Be Made From Injection Moulds

Key Learning Points

Example of components produced using injection moulding.

1.1 Example Of Components Produced Using Injection Moulding

There are many types of plastics available, which can be used to manufacture different types of components. Injection moulds can be used to manufacture various types of products such as: electrical plugs, bins, baths, furniture, kettles, toys, cups, plates, knobs, housings for computers and photocopiers.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 14, *Plastics*, sec. 14.2, *Types of plastics*, p. 235.
ISBN-13: 9780750660730

2.0 Difference Between Thermoplastic And Thermoset Plastics

Key Learning Points

Distinction between thermoplastic and thermoset polymer. Application of thermoplastic polymers.

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 Application Of Thermoplastic Polymers

Plastics are divided into two classes, thermoplastics and thermosetting plastics.

Thermoplastics – These plastics become soft and pliable when heated and returns to its hardened state when cool. The heating and cooling process can be carried out a number of times without causing the plastic to deteriorate. These plastics include nylon, perspex, vinyl, cellulous, polythene and polystyrene.

Thermoset plastics – These plastics go through a chemical change when heated which 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.

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

3.0 Describing The Mould Cycle In A Moulding Machine

Key Learning Points

Principle of injection moulding. Stages of a moulding cycle: plasticization, mould filling, packing, solidification and ejection, cycle time.

3.1 Principle Of Injection Moulding

The injection moulding process can be used for thermoplastic or thermosetting materials, but it is mainly used for thermoplastic materials. The plastic moulding material is available in the form of powder or granules, which is placed into the hopper of the injection moulding machine. The principle of injection moulding is to heat the moulding in a heating cylinder and then inject the plasticised material into the mould cavity, where it cools to form the required shape.

3.2 Stages Of A Moulding Cycle: Plasticization, Mould Filling, Packing, Solidification And Ejection, Cycle Time

Plasticisation - The moulding material is gravity fed from the hopper into a cylindrical chamber which heats the plastic. A screw inside the chamber rotates and carries the moulding material to the opposite end of the chamber. The heaters and the frictional forces cause the moulding material to soften. As the material builds up the screw moved back and stops rotating. The amount of material is known as the shot size. The previously moulded part is ejected from the mould at this stage and the mould is closed again.

Mould filling - The screw is moved towards the mould, which pushes the moulding material under pressure into the mould cavity. The process is then repeated to produce another part.

Packing – As the screw is moved towards the mould it pushes the moulding material under pressure into the mould cavity.

Solidification – The mould remains closed while the part cools and solidifies. Waterways within the mould provide a means for water to cool the mould and the part.

Ejection - When the part has solidified the mould opens and the part is ejected.

Cycle Time – This is the time it takes to make a part.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 14, *Plastics; Injection moulding*, p. 247.
ISBN-13: 9780750660730

4.0 Identifying The Parts Of An Injection Mould

Key Learning Points

Identification of and function of the following injection mould component parts: cavity plate, core plate, cavity insert, core insert, sprue bush location ring, ejector plates, risers, bolster, return pins, sprue puller, runner, waterways, guiding system, gates.

4.1 Identification Of And Function Of The Following Injection Mould Component Parts

The injection mould is made up of various parts, such as the *Cavity* and *Core plates* house the *Cavity and Core inserts*. The top and bottom plates are called the *Bolster or Backing Plates*. The *Sprue bush* and *Location ring* are located in the top backing plates or bolster. The *Ejector plates, Ejector pins and Return Pins* are located in the moving half of the mould.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 14, *Plastics; Injection moulding*, p. 247.
ISBN-13: 9780750660730

5.0 The Functions Of The Various Parts Of An Injection Mould

Key Learning Points

Transformation of plastic as heat is applied. The functions of the various parts of an injection mould.

5.1 Transformation Of Plastic As Heat Is Applied

The moulding material is fed into a cylindrical chamber which heats the plastic. A screw inside the chamber rotates and carries the moulding material to the opposite end of the chamber. The heaters and the frictional forces cause the moulding material to soften.

Plastic is solid at normal temperatures and becomes soft and can be pliable at higher temperatures. The moulding process is done by applying heat and pressure. Plastic is made up of molecules which are arranged in long chains. They soften when heated and harden when cooled. This process can be repeated again and again. This type of plastic is called a thermoplastic. Another type of plastic is the thermoset plastic, which softens when heated and hardens when cooled, but cannot be softened again. During the heating process a chemical reaction takes place and the long chains of molecules become cross linked, which is permanent

5.2 The Functions Of The Various Parts Of An Injection Mould

The injection mould is made up of various parts, which are as follows:

- *Cavity plate* – This plate that holds and locates the mould cavity.
- *Core plate* - This plate that holds and locates the core cavity.
- *Cavity insert* – highly polished cavity that forms the external surface of the moulded part.
- *Core insert* – this is a polished core that forms the internal surface of the finished moulded part.
- *Sprue bush* – Sits into the nozzle of the injection machine and has a tapered hole through which the plasticised material is forced into the sprue and runner.
- L*ocation ring* – Locates the centre of the injection machine so that the sprue bushing and the nozzle are aligned and fits into the counterbore in the fixed clamping plate.
- *Ejector plates* - Pushes the ejector pins and return pins at the same time and is mounted to the ejector back plate to form the ejector unit.
- *Ejector pins* – Ejects the moulded part from the mould.
- *Return pins* – Pushes back the ejector plate and ejector pins and ensures that the ejector unit is back in its original position when the mould is closed.
- *Bolster* – These plates are positioned on the top and bottom of the mould and support the injection mould components.
- *Sprue puller*- helps to retain the runner, sprue and the moulded part in the bottom part of the mould when the mould opens, the part is then ejected.
- *Sprue* – This is the vertical tapered hole which is used to inject the mould material into the mould.
- *Runner* – Are the means that the plastic is carried to the mould cavity from the sprue.

- *Gates* – this is a small channel between the runner and the mould cavity.
- *Waterways* – These are water channels in the mould and help to cool the moulded part.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 14, *Plastics; Injection moulding*, p. 247.
ISBN-13: 9780750660730

6.0 Selecting Standard Parts In Catalogues

Key Learning Points

Selection of standard parts from catalogues. Sources of new data and integration of new techniques into work practices.

6.1 Selection Of Standard Parts From Catalogues

As many parts as possible used in the injection mould should be ordered from catalogues. These parts are mass produced and will therefore work out more economical that having to manufacture them in you own Toolroom. These parts include Bolster Plates, Sprues, Location rings, Ejector plates and Ejector and Return Pins.

6.2 Sources Of New Data And Integration Of New Techniques Into Work Practices

New processes and materials are constantly being developed and improved. It is important therefore to keep up to date with the latest information by sourcing new data and techniques from engineering magazines, internet, shows, attending courses, presentations etc.

7.0 Applying Machining Techniques To Achieve Required Surface Finish

Key Learning Points

Ra, N, CLA values and matching machining methods. First and third angle drawings of components, Ra values indicated on component drawings.

7.1 Ra, N, Cla Values And Matching Machining Methods

The drawing will specify the required surface finish. The surface finish can be checked on a surface roughness machine or if this is not available a surface roughness comparator chart can be used to compare the surface finish. The comparator chart consists of a range or machined samples and the corresponding Ra valve.

The *Ra* value is the average height of the peaks and valleys on a metal surface, at the micro scale (0.001mm).

Ra surface measurement is the most common system used, but other systems can also be used. The table below shows the approximate conversion between the different measuring systems:

Ra = CLA **(CLA means centre line average. It is used in Britain and is identical to Ra)**		**Roughness Grade No's** **(N)**
µm	**µin**	
0.40	15.7	N5
0.80	31.4	N6
1.6	63.0	N7
3.2	126.0	N8
6.3	247.0	N9
12.5	485.0	N10

Note: µm = micro metre, µin = micro inch

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 5, *Standards, measurements and gauging*, sec. 5.8, *Surface roughness*, p. 92.
ISBN-13: 9780750660730

7.2 First And Third Angle Drawings Of Components, Ra Values Indicated On Component Drawings

The drawing may also specify the surface finish requirements of the workpiece. The method used to determine the surface finish is to measure the average height of the peaks and valleys of the surface, using a surface measuring machine. The surface roughness is therefore expressed as surface roughness average (Ra) and is measured in micrometers (0.001mm). Surface roughness comparator sets are available and can be used to compare the machined surface of the workpiece and determine an approximate Ra value.

Ref: Simmons, Colin H & Maguire, Dennis E 2004, *Manual of engineering drawing*, 2nd edn, Elsevier Science & Technology, chapter 14, *Graphical symbols*, p.109.
ISBN-13: 9780750651202

In technical drawing there are two systems of projection, First Angle and Third Angle, which are based on a framework of planes at right angles. In first angle projection, each view shows what would be seen by looking on the far side of an adjacent view. In Third angle projection, each view shows what would be seen by looking on the near side of an adjacent view.

Ref: Simmons, Colin H & Maguire, Dennis E 2004, *Manual of engineering drawing*, 2nd edn, Elsevier Science & Technology, chapter 4, *Principles of first and third angle orthographic projection.*
ISBN-13: 9780750651202

Summary

The variety of parts that can be made from injection moulds: There are many types of plastics available, which can be used to manufacture different types of components. Injection moulds can be used to manufacture various types of products such as: electrical plugs, bins, baths, furniture, kettles, toys, cups, plates, knobs, housings for computers and photocopiers.

Difference between thermoplastic and thermoset plastics: Plastics are divided into two classes, thermoplastics and thermosetting plastics. *Thermoplastics* become soft and pliable when heated and returns to its hardened state when cool. *Thermoset plastics* – These plastics go through a chemical change when heated which cannot be reversed.

Describing the mould cycle in a moulding machine: The injection moulding process can be used for thermoplastic or thermosetting materials, but it is mainly used for thermoplastic materials. The plastic moulding material is available in the form of powder or granules, which is placed into the hopper of the injection moulding machine. The principle of injection moulding is to heat the moulding in a heating cylinder and then inject the plasticised material into the mould cavity, where it cools to form the required shape.

Identifying the parts of an injection mould: The injection mould is made up of various parts, such as the *Cavity* and *Core plates* house the *Cavity and Core inserts*. The top and bottom plates are called the *Bolster or Backing Plates.* The *Sprue bush* and *Location ring* are located in the top backing plates or bolster. The *Ejector plates, Ejector pins and Return Pins* are located in the moving half of the mould.

The functions of the various parts of an injection mould: The moulding material is fed into a cylindrical chamber which heats the plastic. A screw inside the chamber rotates and carries the moulding material to the opposite end of the chamber. The heaters and the frictional forces cause the moulding material to soften.

Selecting standard parts in catalogues: As many parts as possible used in the injection mould should be ordered from catalogues. These parts are mass produced and will therefore work out more economical that having to manufacture them in you own Toolroom. These parts include Bolster Plates, Sprues, Location rings, Ejector plates and Ejector and Return Pins.

New processes and materials are constantly being developed and improved. It is important therefore to keep up to date with the latest information by sourcing new data and techniques from engineering magazines, internet, shows, attending courses, presentations etc.

Applying machining techniques to achieve required surface finish: The drawing will specify the required surface finish. The surface finish can be checked on a surface roughness machine or if this is not available a surface roughness comparator chart can be used to compare the surface finish. The comparator chart consists of a range or machined samples and the corresponding Ra valve. The *Ra* value is the average height of the peaks and valleys on a metal surface, at the micro scale (0.001mm).

Suggested Exercises

1. Look around the Toolroom and identify parts that have been injected moulded.
2. What is the main difference between thermoplastics and thermosetting plastics.
3. Sketch a simple mould showing the following parts: Cavity, Core, Backing Plates Location ring, Ejector plates, Ejector pins, Return Pins, Sprue and Runner.
4. What are the stages of the moulding cycle.
5. Sketch a workpiece, showing three views, in both first and third angle projection.

Questions

1. What type of plastic is a Thermoplastic and give examples of these plastics?
2. What type of plastic is a Thermosetting plastic and give some typical uses?
3. Explain briefly the principle of the plastic injection mould.
4. What is the Cavity Insert in an injection mould?
5. What is the Core Insert in an injection mould?

Answers

1. Thermoplastics – These plastics become soft and pliable when heated and returns to its hardened state when cool. The heating and cooling process can be carried out a number of times without causing the plastic to deteriorate. These plastics include nylon, perspex, vinyl, cellulous, polythene and polystyrene.
2. Thermoset plastics – These plastics go through a chemical change when heated which 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.
3. The principle of injection moulding is to heat the moulding in a heating cylinder and then inject the plasticised material into the mould cavity, where it cools to form the required shape.
4. Cavity insert – highly polished cavity that forms the external surface of the moulded part.
5. Core insert – this is a polished core that forms the internal surface of the finished moulded part.

Recommended Additional Resources

Reference Books

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

ISBN-13: 9780750660730

Simmons, Colin H & Maguire, Dennis E 2004, *Manual of engineering drawing*, 2nd edn, Elsevier Science & Technology.

ISBN-13: 9780750651202

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

ISBN-13: 9780582356931