Trade of Toolmaking

Module 5:	Press Tools, Jigs & Fixtures, Mouldmaking
Unit 10:	Mould Assembly
	Phase 2

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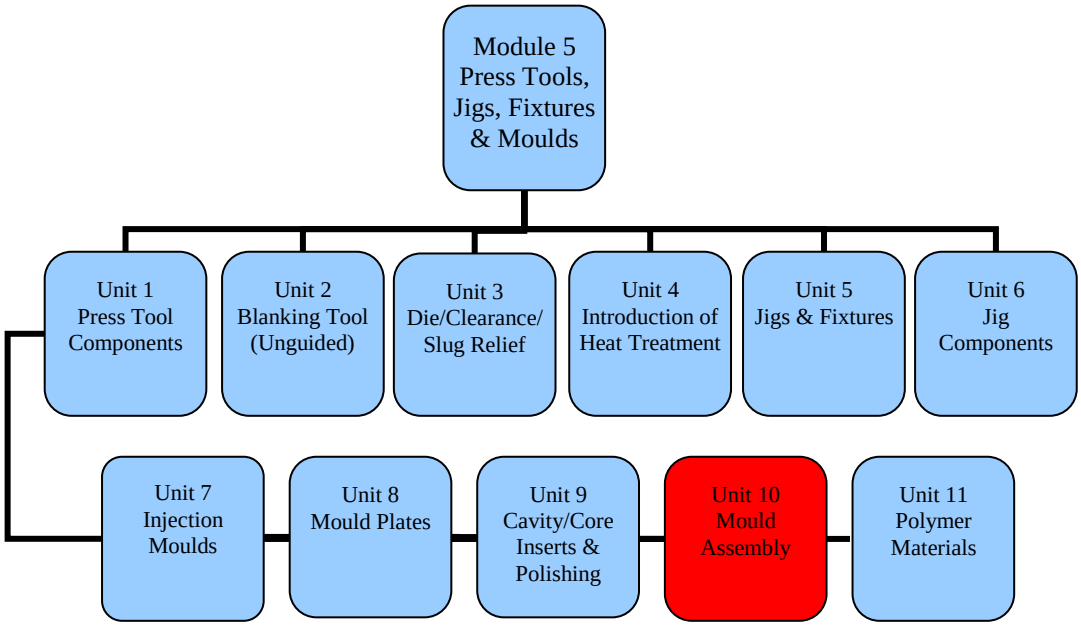
Unit Objective

On completion of this unit you will be able to complete final assembly of mould, describe moulding terms and list the phases of moulding a component.

Introduction

Module five of this course covers Press Tools, Jigs & Fixtures, Mouldmaking. This is the tenth unit in module five and explains how to complete final assembly of a mould, setup the mould on the moulding machine and the first injection moulding trial run. This unit also introduces the techniques associated with analysing the faults and debugging the results.

When the mould has been manufactured to the specified drawing it is setup on the injecting moulding machine. The injection moulded parts are rarely perfect on the first trial run, due to the many variables such as barrel temperature, injection pressure, mould temperature etc., which will need to be adjusted before an acceptable part is produced.



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

- Complete final assembly of mould.
- Verify that the mould is shutting out and the ejector box is moving freely.
- Identify and describe moulding terms.
- List the phases of moulding a component.
- State and apply Pascal's law.
- List safety precautions when working on injection moulds.
- Analyse faults and debug mould resulting in a quality moulding.

1.0 Final Assembly Of Mould

Key Learning Points

Assembly and disassembly techniques. Torque setting for screws.

1.1 Assembly And Disassembly Techniques

The top half of the mould is assembled by inserting the pillars and cavity block into the cavity plate. Assemble the cavity plate onto the back plate with screws. The pillars and cavity block are now secure. The bottom half of the mould is assembled as follows: Insert the core into the core plate and assemble onto back plate with screws. Insert the ejector pin and the return pin into the ejector plate and assemble to the ejector back plate. Assemble the ejector plate assembly into the core plate. Now assemble these sub-assemblies with the back plate. The top and bottom sides of the moulds can now be assembled.

The mould is now fixed onto the moulding machine, the top half to the platen on the nozzle side and the bottom half to the moving side of the machine.

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

1.2 Torque Setting For Screws

The screws should be tightened using a torque wrench to the value set by the manufacture. This will ensure distribution of forces and avoids warping of bending in the plates.

2.0 Verifying That The Mould Is Shutting Out And Ejector Box Is Moving Freely

Key Learning Points

Mould shutting off procedure.

2.1 Mould Shutting Off Procedure

When the mould is first setup, flash on one area of a part may indicate that the mould is not shutting off. If this occurs then the clamping pressure may need to be increased or the mould needs to be dimensionally inspected and modified if required. The ejector box and ejector pins should be moving freely during injection moulding and ejection of parts. If the ejector box is not moving freely then the mould assembly needs to be inspected and modified if required.

3.0 Identifying And Describing Moulding Terms

Key Learning Points

Mould term: shot volume, injection pressure, melt temperature, shut height, cooling cycle shrinkage, location ring diameter, sprue radius and clamp force.

3.1 Mould Term: Shot Volume, Injection Pressure, Melt Temperature, Shut Height, Cooling Cycle Shrinkage, Location Ring Diameter, Sprue Radius And Clamp Force

Shot volume - This is the amount of material required to fill the cavities, runners and sprue of the injection mould. *Injection pressure* – When shot volume has built up behind the nozzle, the screw in the barrel stops rotating. It then moves forward pushing the plastic material into the mould under pressure. *Melt temperature* – This is the temperature that the plastic material must be before it is injection moulded. The heating chamber varies from 120C to 260C, depending on the type of moulding material being used and the shot volume required. *Cooling cycle* – The time it takes for the moulded part to solidify from when it is injected into the mould. *Shrinkage* – All moulded parts will shrink when cooled. This is because the density of the material varies from the processing temperature to room temperature. Therefore the mould cavity need to be machined oversize in order allow for shrinkage, which varies between different materials. *Location ring diameter* – The location ring is located into the top plate of the mould and locates and centralises the mould into the fixed platen.

Spue radius – The plastic material is injected into the mould through the sprue, it is therefore important the radius in the sprue is the same as that of the nozzle in the injection moulding machine. *Clamp force* - The clamping unit in the machine must be able to supply enough locking force to keep the mould shut during the injection phase, otherwise the mould will part and molten material will flash over the mould split line.

4.0 The Phases Of Moulding A Component

Key Learning Points

Mould sequence and operation. Mould cycle, mould close, injection, cooling of component, opening of mould, ejection of component.

4.1 Mould Sequence And Operation

The injection moulding machine is fully automated. The plastic material in the form of powder or granules is feed from the hopper into the heated barrel. The plastic material is melted in the barrel by a combination of heat and pressure. The rotating screw pushes the material forward where it collects behind the nozzle. The mould is clamped under pressure and the screw is pushed forward and the molten plastic is injected into a mould under pressure. The plastic part solidifies in the mould and when cooled is ejected.

4.1 Mould Cycle, Mould Close, Injection, Cooling Of Component, Opening Of Mould, Ejection Of Component

The mould cycle is as follows:

- *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 become plastic. As the material builds up the screw moved back and stops rotating. The amount of material is known as the shot size.
- *Mould Close* – The plasticisation stage takes place at the same time as the previously moulded part is cooling in the mould. The moulded part is ejected from the mould at this stage and the mould is closed again under pressure.
- *Injection* - The screw is moved towards the mould, which pushes the moulding material under pressure into the mould cavity.
- *Cooling* – 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.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 14, *Plastics; Injection moulding*, p. 247.
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5.0 Stating And Applying Pascal's Law

Key Learning Points

Application of Pascal's law in injection moulding.

5.1 Application Of Pascal's Law In Injection Moulding

Pascal's law states that a change in the pressure of an enclosed incompressible fluid is transmitted to every part of the fluid and to the surfaces of its container.

This also applies to the molten plastic material being injected into the mould cavity. The pressure is provided by the screw moving forward and pushing the molten material into the mould and as explained above the pressure of the molten plastic will be the same as the plastic in the heated barrel and in the mould cavity until it starts to solidify.

6.0 Safety Precautions When Working On Injection Moulds

Key Learning Points

Safety procedures in mould handling, setup and testing. Manual handling and safety requirements.

6.1 Safety Procedures In Mould Handling, Setup And Testing

Safely Controls: The injection moulding machine should be operated by a qualified person. The safety rules are as follows:

- Know how to shut-off the machine in an emergency.
- Ensure that all guards are in position.
- Ensure that the extraction equipment is in place and switched on.
- Wear eye protection in case of mould blow out.
- Wear suitable heat resistant gloves.
- Ensure that power is turned off prior to adjusting or removing mould.
- Use suitable lifting equipment for heavy moulds.
- When removing the mould ensure that the injection unit is retracted.

6.2 Manual Handling And Safety Requirements

It is important to keep the work area and the workshop clean and tidy. All tool and equipment must be returned to their respective toolbox or storage area when not in use. Always wear safety glasses when using power tools and tie back long hair or loose clothing. Ensure that the floor is kept free of debris, oil and coolant spills. Clean up spills immediately.

Care and use of hand tools:

- Select the correct size tool for the job.
- Do not use worn or damaged tools.
- Maintain tools in good condition.
- Store and carry tools safely.

7.0 Analysing Faults And Debug Mould Results In A Quality Moulding

Key Learning Points

Debug of mould: analysis of faults. Shrinkage: due to thermal contraction, polymer properties. Verify shrinkage: measurement of components, shrinkage ratios. Use of handbooks and data sheets to source polymer material properties. Forces in a mould – injection pressure. Calculation of volume of plastic required per cycle of the mould.

7.1 Debug Of Mould: Analysis Of Faults

When the mould is manufactured to the specified drawing, it is setup on the injecting moulding machine. It is important that the mould setup by a qualified person and a trial run is performed. The injection moulded parts are rarely perfect on the first trial run, as there are many variables in injection moulding such as barrel temperature, injection pressure, mould temperature etc., which will need to be adjusted before producing the perfect part.

The following is a list of some of problems that may occur when a part is injected moulded and actions that can be taken to eliminate the problems:

- *Part shrinkage* - Increase the injection pressure, holding pressure and the mould temperature.
- *Excessive flash* - Decrease shot size, holding pressure and injection pressure.
- *Flow lines* - Increase injection speed, injection pressure and holding pressure.
- *Nozzle freezes up* - Decrease the mould temperature and the barrel temperature.
- *Orange peel effect* - Increase injection pressure, holding pressure, barrel temperature and mould temperature.
- *Part sticking in Mould* - Polish mould, decrease holding pressure and increase mould temperature.
- *Trapped gas* - Decrease barrel temperature, injection speed, holding and injection pressure.
- *Warped Part* - Increase the mould temperature, barrel temperature and screw back pressure.

7.2 Shrinkage: Due To Thermal Contraction, Polymer Properties

All moulded parts will shrink when cooled. This is because the density of the material varies from the processing temperature to room temperature. Therefore the mould cavity need to be machined oversize in order allow for shrinkage, which varies between different materials.

7.3 Verify Shrinkage: Measurement Of Components, Shrinkage Ratios

The shrinkage ratio can be verified by measuring a feature in the mould such as the diameter of the mould cavity and then measure the outside diameter of the moulded part. Divide the value of the moulded part by the mould cavity diameter to get the shrinkage ratio.

7.4 Use Of Handbooks And Data Sheets To Source Polymer Material Properties

Manufacturer's handbooks and data sheets should be used when sourcing polymer materials. Depending on the material being used, the data sheets will recommend the settings for variables such as the barrel temperature, injection pressure, mould temperature etc.

7.5 Forces In A Mould – Injection Pressure

During the mould setup, the primary injection pressure can be set to range of between 6.0 to 11.0 MPa. The pressure may be raised or lowered depending on the results of the trial run.

7.6 Calculation Of Volume Of Plastic Required Per Cycle Of The Mould

When using the mould for the first time start with a small shot weight and fills gradually until the mould is 95 to 99% full. By starting with a less than full shot and gradually working up to the full shot, there is less chance of damaging the mould.

Summary

Final assembly of mould: The top half of the mould is assembled by inserting the pillars and cavity block into the cavity plate. Assemble the cavity plate onto the back plate with screws. The pillars and cavity block are now secure. The bottom half of the mould is assembled as follows: Insert the core into the core plate and assemble onto back plate with screws. Insert the ejector pin and the return pin into the ejector plate and assemble to the ejector back plate. Assemble the ejector plate assembly into the core plate. Now assemble these sub-assemblies with the back plate. The top and bottom sides of the moulds can now be assembled.

Verifying that the mould is shutting out and ejector box is moving freely: When the mould is first setup, flash on one area of a part may indicate that the mould is not shutting off. If this occurs then the clamping pressure may need to be increased or the mould needs to be dimensionally inspected and modified if required. The ejector box and ejector pins should be moving freely during injection moulding and ejection of parts. If the ejector box is not moving freely then the mould assembly needs to be inspected and modified if required.

Identifying and describing moulding terms: There are a number of terms used in injection moulding, some of which are as follows: *Shot volume* - This is the amount of material required to fill the cavities, runners and sprue of the injection mould. *Injection pressure* – When shot volume has built up behind the nozzle, the screw in the barrel stops rotating. It then moves forward pushing the plastic material into the mould under pressure. *Melt temperature* – This is the temperature that the plastic material must be before it is injection moulded. The heating chamber varies from 120C to 260C, depending on the type of moulding material being used and the shot volume required. *Cooling cycle* – The time it takes for the moulded part to solidify from when it is injected into the mould. *Shrinkage* – All moulded parts will shrink when cooled. This is because the density of the material varies from the processing temperature to room temperature. Therefore the mould cavity need to be machined oversize in order allow for shrinkage, which varies between different materials.

The phases of moulding a component: The injection moulding machine is fully automated. The plastic material in the form of powder or granules is feed from the hopper into the heated barrel. The plastic material is melted in the barrel by a combination of heat and pressure. The rotating screw pushes the material forward where it collects behind the nozzle. The mould is clamped under pressure and the screw is pushed forward and the molten plastic is injected into a mould under pressure. The plastic part solidifies in the mould and when cooled is ejected.

Stating and applying Pascal's law: Pascal's law states that a change in the pressure of an enclosed incompressible fluid is transmitted to every part of the fluid and to the surfaces of its container.

Safety precautions when working on injection moulds:

The injection moulding machine should be operated by a qualified person. The safety rules are as follows:

- Know how to shut-off the machine in an emergency.
- Ensure that all guards are in position.
- Ensure that adequate extraction equipment is in place and switched on.
- Wear eye protection in case of mould blow out.
- Wear suitable heat resistant gloves.
- Ensure that power is turned off prior to adjusting or removing mould.

- Use suitable lifting equipment for heavy moulds.
- When removing the mould ensure that the injection unit is retracted.

Suggested Exercises

1. Sketch a basic mould assembled and mounted onto the injection moulding machine and label the main features.
2. State Pascal's Law.
3. What safety precautions should you take when operating an injection mould?
4. Why does the mould cavity need to be bigger that the finished moulded part?
5. How is the percentage ratio calculated?

Questions

1. Explain the following injection moulding terms: (i) Shot volume, (ii) Injection pressure and (iii) Melt temperature.
2. List the main stages of the injection moulding cycle.
3. What is Plasticisation?
4. Why is the clamping force important when injection moulding parts?
5. If the mould part is showing excessive shrinkage, what adjustments can be made to the injection moulding machine.

Answers

1. (i) Shot volume - This is the amount of material required to fill the cavities, runners and sprue of the injection mould. (ii)Injection Pressure – When shot volume has built up behind the nozzle, the screw in the barrel stops rotating. It then moves forward pushing the plastic material into the mould under pressure. (iii) Melt temperature – This is the temperature that the plastic material must be before it is injection moulded.
2. Plasticisation - Mould Close - Injection - Cooling - Ejection.
3. Plasticisation - 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 become plastic, which is soft and ready for injection.
4. The clamping unit in the machine must be able to supply enough locking force to keep the mould shut during the injection phase, otherwise the mould will part and molten material will flash over the mould split line.
5. Increase the injection pressure, the holding pressure and/or the mould temperature.

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