Trade of Toolmaking

Module 5:	Press Tools, Jigs & Fixtures, Mouldmaking
Unit 9:	Cavity/Core Inserts & Polishing
	Phase 2

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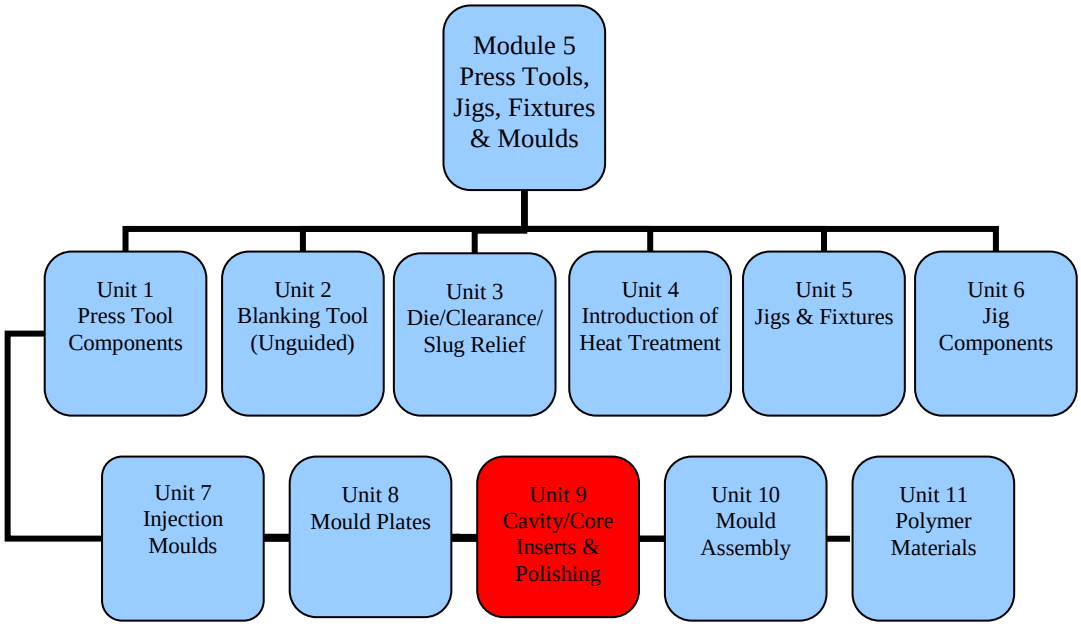
Unit Objective

On completion of this unit you will be able to describe the various functions of an injection mould and polishing process. The advantages of polishing a mould cavity and core are also explained.

Introduction

Module five of this course covers Press Tools, Jigs & Fixtures, Mouldmaking. This is the ninth unit in module five and explains various functions of an injection mould and how to machine the mould components. This unit also introduces the techniques associated with polishing the mould core and cavity.

Polishing is a specialised process, which is time consuming and therefore expensive. It requires patience and skill, but if done properly will result in a perfect mirror finish. The function of a polished surface in the mould is not just to produce a good finish on the moulded part but it also helps the plastic to flow during the injection process and allows easier ejection of the part.



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

- Describe function of mould sprue, runner and gate and identify various types.
- Turn core/cavity inserts and guide pillars.
- Measure core and cavity area before and after polishing.
- Identify how polishing removes material from cavity/core inserts.
- Apply a polishing medium to achieve the Ra finish required.
- List and describe types of polishing media.
- List the advantages of polishing cavity/core inserts.
- Protect an area that requires to be kept sharp/different surface finish.

1.0 The Functions Of Mould Sprue, Runner And Gate

Key Learning Points

Description of moulding terms such as: shut off, vents, exhaust, flash, witness line draft, polishing allowance, Ra, fixed half, moving half and split line.

1.1 Description Of Moulding Terms Such As: Shut Off, Vents, Exhaust, Flash, Witness Line Draft, Polishing Allowance, Ra, Fixed Half, Moving Half And Split Line

- *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.
- *Shut off* - In order to create an opening in the side of thin walled moulded part, the faces of the mould must slide past each other until the mould closes where they create a seal which creates a hole in your part. The minimum draft of 3 degrees allows greater clearance for the sealing faces on opposite sides of the mould to pass by one another without the risk of galling and wear.
- *Vents* – When the plastic is injected into the mould, gases can be trapped and cause burn marks on the part. Therefore vents need to be added in order to allow the gas to escape. The vent is normally about 0.07mm deep x 5mm wide.
- *Exhaust* – It is important to allow gasses to escape.
- *Flash* – If the mould plates do not shut off properly or if there is a gap between the ejector pin and core, the plastic is forced into this space. The flash will be left on the part when moulded.
- *Draft* – In order for the part to be removed easily from the mould, the walls of the part need to be tapered.
- *Witness Line* – This is the mark left behind when the gate is removed.
- *Polishing Allowance* – Material is removed during polishing, therefore additional material needs to be left on the surface during the machining process.
- *Ra* – The method used to determine the surface texture or 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.
- *Fixed Half* – This is the top half of the mould, which is attached to the injection side of the moulding machine. The plastic is injected into this side of the mould through the sprue.
- *Moving Half* – This is the bottom half of the mould and houses the ejector plate and pins. When this half is moved back the ejector pin pushes out the part.

- *Split Line* – This is where the cavity plate and core plate join to close off the mould. Upon inspection of the part, a fine line can be seen on the 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

2.0 Turning Core/Cavity Inserts And Guide Pillars

Key Learning Points

Turn core/cavity inserts and guide pillars.

2.1 Turn Core/Cavity Inserts And Guide Pillars

The mould core forms the inside shape of the moulded part and the cavity forms the external shape of the part. The guide pins sit into the mould cavity plate and locate and guide the moving half of the mould. These parts need to be hardened and polished, therefore tool steel should be used. The material specification should be on the drawing. For the core, secure the bar stock in a 3-jaw chuck and face it off. The central bore needs to be drilled and reamed, as this will house the ejector pin and allow it to slide without causing a flash. The external profile is turned using a fine feed on the final cut so as to produce a good finish. A shoulder is also required to secure it in the core plate. The core is then parted off. The cavity is bored out to good finish. It is important to radius the corners and per drawing. The core is parted off as explained above. The guide pillars are turned to a very tight tolerance and parted off leaving a shoulder.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 9, *Turning*, p. 140.
ISBN-13: 9780750660730

3.0 Measuring Core And Cavity Area Before And After Polishing

Key Learning Points

Use Ra charts/surface charts to determine appropriate surface finish.

3.1 Use Ra Charts/Surface Charts To Determine Appropriate Surface Finish

Surface roughness comparator sets are available and can be used to compare the machined surface of the workpiece and determine an approximate Ra value. A surface measuring machine can also be used.

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

4.0 Identifying How Polishing Removes Material From Cavity/Core Inserts

Key Learning Points

Identify how polishing removes material.

4.1 Identify How Polishing Removes Material

When the mould core and cavity has been turned and hardened, it then needs to be polished. If for example it has a surface finish of Ra 2.0 before polishing, this means that the average height of the peaks and valleys on the surface is 0.002mm. During the polishing process fine emery paper is used to remove the peaks and then polishing sticks and polishing compound is used. If all these peaks are removed then it means that up to 0.002mm will removed from each surface. This can be checked by checking the surface on the surface roughness machine or a comparator chart before and after polishing. The amount of material removed can be checked by measuring the diameter of the mould cavity with a internal micrometer before and after polishing.

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

5.0 Applying A Polishing Medium To Achieve The Ra Finish Required

Key Learning Points

Methods of applying polishing mediums such as: by polishing sticks, pneumatic buffers, paper, wool.

5.1 Methods Of Applying Polishing Mediums Such As: By Polishing Sticks, Pneumatic Buffers, Paper, Wool

The first step in polishing the mould cavity and core is to use fine grade emery paper, starting with 150 to 350 grit and then finishing with 1200 to 1500 grit paper. Prior to using the polishing compound it is important to clean the mould core or cavity to remove all abrasive particles. The polishing compound also contains abrasives, but these are much smaller particles and range from 120 to 2000 grit. The bigger the grit number the finer the particle size.

Starting with the coarser grit polishing compound e.g. 120, apply it to a polishing stick. Start polishing in the difficult areas such as corners and fillets and then move to the side walls. When the complete surface of the core or cavity has been polished, thoroughly clean the area to remove all traces of the 120 grit compound. A finer grade polishing compound is now used by applying it to a new polishing stick. Pneumatic or electrical driven buffers can also be used with the polishing compound.

6.0 Describing Different Types Of Polishing Media

Key Learning Points

Use appropriate polishing media.

6.1 Use Appropriate Polishing Media

The polishing compound contains abrasives, which range from 120 to 2000 grit. The bigger the grit number the finer the particle size. The abrasive material can be made from boron carbide, aluminium oxide or silicon carbide. The abrasive is then mixed with an oil based paste to produce the polishing compound. For more expensive higher cost moulds, diamond compound can be used.

7.0 The Advantages Of Polishing Cavity/Core Inserts

Key Learning Points

Advantages of polishing such as: ease of ejection, surface finish requirements on the product, improved flow of plastic materials. Coefficient of friction: reduction of friction.

7.1 Advantages Of Polishing Such As: Ease Of Ejection, Surface Finish Requirements On The Product, Improved Flow Of Plastic Materials

Polishing the mould to a mirror finish takes many hours and need to be carried out by a skilled operator and is expensive. The advantages or polishing a mould core or cavity to a mirror finish are as follows:

- Provides a good surface finish on the moulded part. The surface finish on the product depends on the surface finish of the mould. For a moulded part, the external surface may require a better finish than the inside. Therefore the mould cavity will need to be more highly polished than the core.
- A polished finish on the core and cavity will allow for easier ejection of the part. For this reason the internal surface of a moulded part will need a polished finish, even though it has no functional requirement other that ease of ejection of the part from the mould. The core then only needs be polished adequately in order to allow ejection, but will not need to be polished to the mirror finish similar to that of the mould cavity.
- A polished finish will allow the plastic to flow easier when it is injected into the mould cavity. A rougher surface will cause the plastic drag on the surface and will result in poor finish on the part. The reason for the plastic not flowing on the rougher surface is due to friction.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 14, *Plastics; Moulding processes*, p. 245.
ISBN-13: 9780750660730

7.2 Coefficient Of Friction: Reduction Of Friction

Friction is a force that resists motion between two surfaces, in this case one surface is the mould cavity and the other surface is that of the plastic material flowing over it. A highly polished mould cavity will allow the plastic to flow easily over the surface and this will result in a good finish on the moulded part. A rougher surface on the surface of the mould cavity will result in greater friction between the two materials and thus produce a poor finish on the surface of the moulded part.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 14, *Plastics; Moulding processes*, p. 245.
ISBN-13: 9780750660730

8.0 Protecting An Area That Requires To Be Kept Sharp/Different Surface Finish

Key Learning Points

Protecting non polished areas.

8.1 Protecting Non Polished Areas

When the mould cavity is being polished it is important to keep the corners sharp, as rounded edges will show up as a split line on the moulded part. This is done by working from the bottom of the cavity upwards when polishing with the polishing compound and polishing stick. Using a hard polishing stick at the edges will also protect it from being eroded away.

Summary

The functions of mould sprue, runner and gate: *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.

Turning core/cavity inserts and guide pillars: The mould core forms the inside shape of the moulded part and the cavity forms the external shape of the part. The guide pins sit into the mould cavity plate and locate and guide the moving half of the mould. These parts need to be hardened and polished, therefore tool steel should be used.

Measuring core and cavity area before and after polishing: Surface roughness comparator sets are available and can be used to compare the machined surface of the workpiece and determine an approximate Ra value. A surface measuring machine can also be used.

Identifying how polishing removes material from cavity/core inserts: When the mould core and cavity has been turned and hardened, it then needs to be polished. If for example it has a surface finish of Ra 0.1 before polishing, this means that the average height of the peaks and valleys on the surface is 0.001mm. During the polishing process fine sand paper is used to remove the peaks and then polishing sticks and polishing compound is used. If all these peaks are removed then it means that and average of 0.001mm is removed from each surface.

Applying a polishing medium to achieve the Ra finish required: The first step in polishing the mould cavity and core is to use fine grade emery paper, starting with 150 to 350 grit and then finishing with 1200 to 1500 grit paper. Prior to using the polishing compound it is important to clean the mould core or cavity to remove all abrasive particles. The polishing compound also contains abrasives, but these are much smaller particles and range from 120 to 2000 grit. The bigger the grit number the finer the particle size.

Describing different types of polishing media: The polishing compound contains abrasives, which range from 120 to 2000 grit. The bigger the grit number the finer the particle size. The abrasive material can be made from boron carbide, aluminium oxide or silicon carbide. The abrasive is then mixed with an oil based paste to produce the polishing compound. For more expensive higher cost moulds, diamond compound can be used.

The advantages of polishing cavity/core inserts: Polishing the mould to a mirror finish takes many hours and need to be carried out by a skilled operator and is expensive. The advantages or polishing a mould core or cavity to a mirror finish are as follows:

- Provides a good surface finish on the moulded part.
- A polished finish on the core and cavity will allow for easier ejection of the part
- A polished finish will allow the plastic to flow easier when it is injected into the mould cavity.

Protecting an area that requires to be kept sharp/different surface finish: When the mould cavity is being polished it is important to keep the corners sharp, as rounded edges will show up as a split line on the moulded part. This is done by working from the bottom of the cavity upwards when polishing with the polishing compound and polishing stick. Using a hard polishing stick at the edges will also protect it from being eroded away.

Suggested Exercises

1. What are the functions of the Sprue, the Runner and the Gate?
2. Why do the guide pins and ejector pins need to be hardened and polished?
3. What are the reasons for polishing the mould cavity?
4. List three abrasive materials that can be used in the polishing paste.

Questions

1. What are surface roughness comparator sets used for?
2. What are the advantages of polishing the cavity of a mould?
3. What is friction and how does it relate to mould cavities?
4. Explain the following: (i) Fixed Half and (ii) Moving Half of the mould.
5. Explain why vents may be required in an injection mould.

Answers

1. Surface roughness comparator sets are available and can be used to compare the machined surface of the workpiece and determine an approximate Ra value.
2. The advantages of polishing the mould cavity are as follows: (i) Provides a good surface finish on the moulded part. (ii) A polished finish on the core and cavity will allow for easier ejection of the part. (iii) A polished finish will allow the plastic to flow easier when it is injected into the mould cavity.
3. Friction is a force that resists motion between two surfaces, in this case one surface is the mould cavity and the other surface is that of the plastic material flowing over it. A highly polished mould cavity will allow the plastic to flow easily over the surface and this will result in a good finish on the moulded part.
4. (i) The Fixed Half is the top half of the mould, which is attached to the injection side of the moulding machine The plastic is injected into this side of the mould through the sprue.
   (ii) The Moving Half is the bottom half of the mould and houses the ejector plate and pins. When this half is moved back the ejector pin pushes out the part.
5. When the plastic is injected into the mould, gases can be trapped and cause burn marks on the part. Therefore vents need to be added in order to allow the gas to escape.

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