Trade of Toolmaking	
Module 5:	Press Tools, Jigs & Fixtures, Mouldmaking
Unit 8:	Mould Plates
	Phase 2

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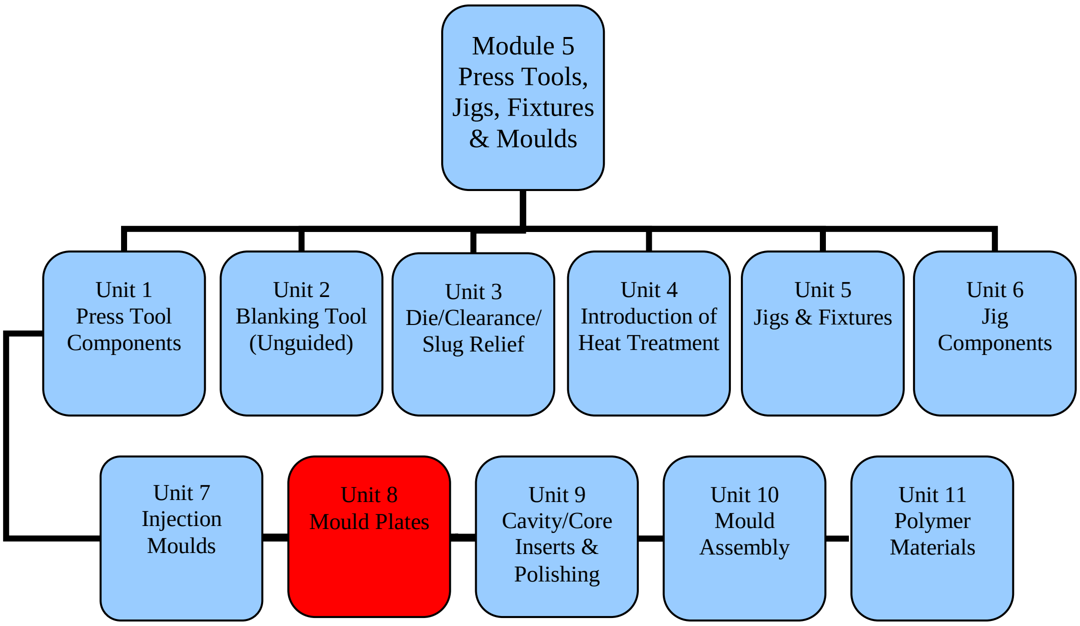
Unit Objective

On completion of this unit you will be able to machine and assemble mould parts as specified on the drawing.

Introduction

Module five of this course covers Press Tools, Jigs & Fixtures, Mouldmaking. This is the eight unit in module five and explains how to machine and assemble the mould parts to the correct drawing specification. Some of the components in the mould will require a ground finish, which will be specified on the drawing with the appropriate symbol, Ra value and a note specifying the process. These surface finish specifications must be understood prior to machining the mould parts. To achieve the required fits between parts such as the pillars and guide holes, the limits and fits system is used. The drawing will specify the required tolerances using a letter and a number, therefore it is important to understand the drawing specification and how to read the limits and fits data sheet.

The drawing will also specify the material type and the heat treat requirements. Parts such as the cavity and core need to be hardened and polished, therefore tool steel is required, which will need to be heat treated. Most of the other plates can be machined form mild steel. Catalogues can be used to source other parts such as pillars and ejector pins.



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

- Apply the correct machining techniques to achieve Ra finish required.
- Apply the correct machining techniques to achieve requirements on geometric tolerances.
- Plan sequence of manufacture of various mating parts utilising the appropriate system of limits and fits.
- Machine the various details to allow assembly and operation of sample tool.
- Select the different machining methods/machines taking into account the variety of steels and hardnesses.

1.0 Applying Correct Machining Techniques To Achieve Ra Finish Required

Key Learning Points

Ra values and matching machining methods.

1.1 Ra Values And Matching Machining Methods

In order for the mould to function properly it is important that the interface between the cavity and the core plates does not have any gaps that could result in flash when the plastic is injected at high pressure. The surfaces therefore need to be flat and have a good surface finish. The drawing will specify the surface finish requirements of the workpiece. If the surface needs to be ground, then this finishing process will be written beside the surface texture symbol, e.g. *Ground*. The value will be written underneath, e.g. Ra 0.2. A typical precision ground finish that can be achieved ranges from 0.1 to 0.4 micrometres (μm).

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

2.0 Applying Correct Machining Techniques To Achieve Geometric Tolerances

Key Learning Points

Geometric tolerances and machining symbols.

2.1 Geometric Tolerances And Machining Symbols

Geometric tolerancing, uses symbols such as positional, perpendicularity, symmetry, squareness, parallelism, etc, on drawings to define the form and size of a tolerance zone within which the feature needs to be contained.

In order that the mould to function properly, it is important that components such as pillars and ejector pins slide in their respective bores, but also that they are positioned correctly. This is done by specifying a positional tolerance for each of these features on the drawing. The bores also need to be perpendicular to the surface of the plate, therefore a perpendicular tolerance may also need to be specified on the drawing. Prior to machining these bores on a milling machine it is important that the head of the machine is square and the vice is clocked correctly. The holes are drilled and reamed to size.

Ref: Simmons, Colin H & Maguire, Dennis E 2004, *Manual of engineering drawing,* 2nd edn, Elsevier Science & Technology, chapter 20, *Geometric tolerancing and datums*, p. 160.
ISBN-13: 9780750651202

3.0 Planning Sequence Of Manufacture Utilising Appropriate System Of Limits And Fits

Key Learning Points

Application of classes of fit and types of fit to mould plates. Selection of a variety of approaches to machining due to tolerances. First and third angle projection, isometric/oblique drawings. Partial staggered sections on engineering drawings. Use of datums.

3.1 Application Of Classes Of Fit And Types Of Fit To Mould Plates

In the *limits and fits system* there are three classes of fit (i) clearance, (ii) transition and (iii) interference fits. For a clearance fit the shaft is always smaller than the hole, which is what is required for moving parts in the mould. To achieve the required fit, the *limits and fits system* is used and required fit is chosen from the data sheet (Ref.: BSI data sheet 4500A).

Cylindrical pillars are used to guide the mould plates during the moulding process. These pillars can be machined or sourced from catalogues, which is more economical. The fit between the pillar and the bore needs to be a close sliding fit, which is a clearance fit. Typical tolerance bands for a high precision fit are H7/g6. The drawing will specify 'H7' beside the bore dimension and 'g6' beside the shaft diameter.

The 'H7' fit is achieved by drilling and then reaming the hole. The reamer will ensure a good surface finish and the diameter will have the required tolerance. When sourcing the pillar from a catalogue read the specification carefully and ensure that the outside diameter has the required clearance fit such as g6 fit.

Ref: Simmons, Colin H & Maguire, Dennis E 2004, *Manual of engineering drawing*, 2nd edn, Elsevier Science & Technology, chapter 19 *Limits and fits*, , p. 153.
ISBN-13: 9780750651202

3.2 Selection Of A Variety Of Approaches To Machining Due To Tolerances

Prior to starting the various machining operations such as milling, turning, grinding and drilling, the drawing should be studied to so that the correct machining operations are used in order to achieve the required tolerances and the finish required. For example, if the top surface of a steel plate needs to be machined to a fine finish of Ra 0.1, then the plate is milled to size, but a grinding allowance is left on the top surface. The top surface of the plate can then be ground to size. Another example are reamed holes, where the holes need to be drilled 0.3mm smaller then the finished size and then the reamer is used to finish the holes to size. It is important to note that the drawing will only specify the finished size and machining method, but the Toolmaker will need to determine on the machining allowance required.

3.3 First And Third Angle Projection, Isometric/Oblique Drawings

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.

Isometric and oblique sketches of components can be generated from first and third angle projected drawings. These sketches help to visualise a part or an assembly prior to manufacture. All isometric drawings are based on three axis spaced 120º apart. One axis is drawn vertical and the side walls are drawn at 30º to the right and left. In oblique drawings one of the faces of the component is parallel to the plane of projection and is drawn in its true shape. The side face is then drawn at 45º to the right.

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

3.4 Partial Staggered Sections On Engineering Drawings

When a feature on a component is hidden or is inside the component and cannot be shown clearly on one of the projected views, then a sectioned view is taken through the part, showing the sectioned view at a right angle to the view.

Ref: Simmons, Colin H & Maguire, Dennis E 2004, *Manual of engineering drawing*, 2nd edn, Elsevier Science & Technology, chapter 8, *Sections and sectional views*, p. 64.
ISBN-13: 9780750651202

3.5 Use Of Datums

The *datum* is described as a reference edge or a point from which measurements are made. When scribing hole centres for example, mark out the centre hole with the vernier height gauge and punch the centre point. The plates are marked out using the same datum edges as those specified on the drawing. When absolute dimensioning is used, it means that all features are marked out and measured from one end of the plate. Normally there are two datum edges, which are at right angles to each other.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 3, *Marking out*, p. 44.
ISBN-13: 9780750660730

4.0 Machining Mould Parts To Allow For Assembly And Operation

Key Learning Points

Machining of mould plates to facilitate correct assembly and operation. Assembly procedures and organisation of surrounding work areas. Assembly of component parts. Materials Handling, machine shop safety. Machine operations, hand skills. Methods of measuring machined areas with hand tools, shadow graph.

4.1 Machining Of Mould Plates To Facilitate Correct Assembly And Operation

The mould core and cavity plates are first machined on a milling machine and then finish ground to size on a grinding machine. Prior to milling the plates, it is important that the head of the machine is square and the vice is clocked correctly using a dial indicator. Mill the plates to size ensuring to leave adequate material on each face for grinding. The holes for the cavity and the core are then drilled and reamed. The large counterbores can be machined with an appropriate size slot drill.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 11, *Milling*, p. 174.
ISBN-13: 9780750660730

4.2 Assembly Procedures And Organisation Of Surrounding Work Areas

Prior to performing any machining or assembly operation, it is important that your surroundings are clean and tidy. Lay out the tools that you will need for the job. Ensure that you have all these parts before assembly. The assembly drawing will list all the parts required, including screws and dowels.

4.3 Assembly Of Component Parts

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. Now assemble the ejector plate assembly into the core plate. Assemble these sub-assemblies with the back plate. The top and bottom sides of the moulds can now be assembled.

4.4 Materials Handling, Machine Shop Safety

When the components have been machined to size, all burrs and sharp edges need to be removed with a file. It is important to keep the work area and the workshop clean and tidy. All tools and equipment must be returned to their respective toolbox or storage area when not in use. Ensure that the floor is kept free of debris, oil and coolant spills. Clean up spills immediately. When using machines always wear safety glasses and tie back long hair or loose clothing.

4.5 Machine Operations, Hand Skills

When the components have been machined to size, all burrs and sharp edges need to be removed with a file. When machining a mould cavity it is important that burrs at the edge of the cavity are carefully removed with a smooth needle file or a honing stone. The edges of the mould cavity need to be kept sharp, so that the moulded part can be produced without a witness line.

4.6 Methods Of Measuring Machined Areas With Hand Tools, Shadow Graph

When inspecting a mould core, it can be setup on a shadow graph. The part is setup on the table and a beam of light shines onto the part. A shadow is projected onto a mirror which is then magnified and displayed on a screen, which are normally magnified to 5:1 or 10:1. The part can be measured by moving the part between the cross hairs on the screen. A reading can be taken from graduations on the hand dials or a digital readout, if fitted. To check radii, templates can be used and the measurements read directly from the templates. For radiused corners and edges that do not need to be as accurate, hand held radius gauges can be used.

5.0 Selecting Different Machining Methods For A Variety Of Steels And Hardenesses

Key Learning Points

Application of best approach to machining the specified mould plates.

5.1 Application Of Best Approach To Machining The Specified Mould Plates

For mould parts such as the backing plates, ejector plates and core and cavity plates mild steel is used and the parts can be machined to size on a milling machine. For parts such as the cavity and the core tool steel should be used. The tool steel is supplied in an annealed state so that it can be machined on the mill or lathe. It is hardened in a furnace and then ground to size. For pillars and ejector pins it is more economical to order from a catalogue.

Summary

Applying correct machining techniques to achieve Ra finish required: In order for the mould to function properly it is important that the interface between the cavity and the core plates does not have any gaps or scratches that could result in flash when the plastic is injected at high pressure. The surfaces therefore need to be flat and have a good surface finish. The drawing will specify the surface finish requirements of the workpiece. If the surface needs to be ground, then this finishing process will be written beside the surface texture symbol, e.g. *Ground*. The value will be written underneath, e.g. Ra 0.2. A typical precision ground finish that can be achieved ranges from 0.1 to 0.4 micrometres (µm).

Applying correct machining techniques to achieve geometric tolerances: Geometric tolerancing, which uses symbols such as positional, perpendicularity, symmetry, squareness, parallelism, etc, on drawings to define the form and size of a tolerance zone within which the feature needs to be contained.

In order that the mould to function properly, it is important that components such as pillars and ejector pins slide in their respective bores, but also that they are positioned correctly. This is done by specifying a positional tolerance for each of these features on the drawing. The bores also need to be perpendicular to the surface of the plate, therefore a perpendicular tolerance may also need to be specified on the drawing. Prior to machining these bores on a milling machine it is important that the head of the machine is square and the vice is clocked correctly. The holes are drilled and reamed to size.

Planning sequence of manufacture utilising appropriate system of limits and fits: In the *limits and fits system* there are three classes of fit (i) clearance, (ii) transition and (iii) interference fits. For a clearance fit the shaft is always smaller than the hole, which is what is required for moving parts in the mould. To achieve the required fit, the *limits and fits system* is used and required fit is chosen from the data sheet (Ref.: BSI data sheet 4500A).

Cylindrical pillars are used to guide the mould plates during the moulding process. These pillars can be machined or sourced from catalogues, which is more economical. The fit between the pillar and the bore needs to be a close sliding fit, which is a clearance fit. Typical tolerance bands for a high precision fit are H7/g6. The drawing will specify 'H7' beside the bore dimension and 'g6' beside the shaft diameter.

Machining mould parts to allow for assembly and operation: The mould core and cavity plates are first machined on a milling machine and then finish ground to size on a grinding machine. Prior to milling the plates, it is important that the head of the machine is square and the vice is clocked correctly using a dial indicator. Mill the plates to size ensuring to leave adequate material on each face for grinding. The holes for the cavity and the core are then drilled and reamed. The large counterbores can be machined with an appropriate size slot drill.

Selecting different machining methods for a variety of steels and hardenesses:

For mould parts such as the backing plates, ejector plates and core and cavity plates, mild steel is used and the parts can be machined to size on a milling machine. For parts such as the cavity and the core tool steel should be used. The tool steel is bought in an annealed state so that it can be machined on the mill or lathe. It is hardened in a furnace and then ground to size. For pillars and ejector pins it is more economical to order from a catalogue.

Suggested Exercises

1. Use a Surface Roughness Comparator Chart, try to determine the surface roughness of workpieces that you machined.
2. Why is important that the interface between the core plate and the cavity plate does not have any gaps.
3. Using the limits and fits system, what class of fit is a H7/g6.
4. What type of steel is used for the mould cavity.

Questions

1. In the limits and fits system what are the three classes of fit?
2. Explain the difference between first and third angle projection.
3. Explain briefly how the top half of a plastic injection mould is assembled.
4. Explain briefly how the bottom half of a plastic injection mould is assembled.
5. Why is tool steel used in the core and cavity plates of an injection mould.

Answers

1. The three classes of fit (i) clearance, (ii) transition and (iii) interference fits.
2. 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.
3. 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.
4. 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. Now assemble the ejector plate assembly into the core plate. Assemble these sub-assemblies with the back plate.
5. Tool steel can be machined on a mill or a lathe in its softer annealed state, it can then hardened, ground to size and polished. The hardened tool steel can withstand the high pressures and temperatures involved in injection moulding.

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

