Trade of Toolmaking

Module 5:	Press Tools, Jigs & Fixtures, Mouldmaking
Unit 3:	Die/Clearance/Slug relief
	Phase 2

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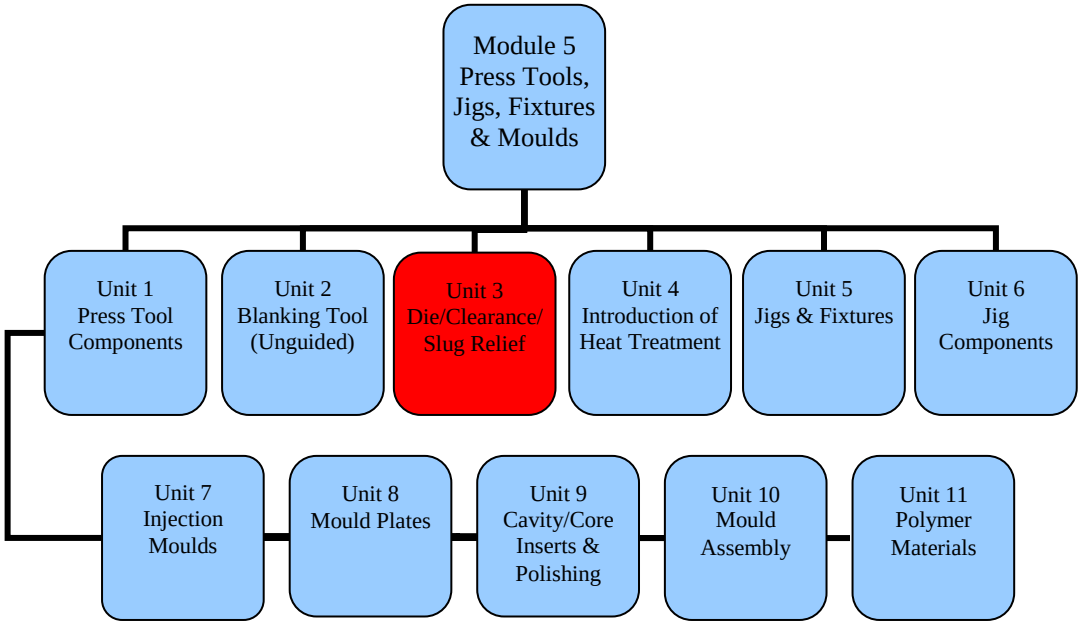
Unit Objective

On completion of this unit you will be able to calculate the punch and die clearance when using various materials. You will understand the relationship between component size to punch and die sizes and describe press tool terminology such as die life, die land and die relief.

Introduction

Module five of this course covers Press Tools, Jigs & Fixtures, Mouldmaking. This is the third unit in module five and explains the importance of using the correct clearance between the punch and die, which will vary depending on the material being blanked. The sharp edges of the punch and die experience very high forces and will wear in time. Therefore adequate land should be left on the die and punch so that a sharp edge can be reground.

Safety requirements must be met when using the power press, which is a powerful machine and potentially very dangerous and should only be setup and used by a qualified person.



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

- Calculate punch and die clearance in relation to material type and thickness.
- Finish by precision machining the cutting area on the punch and die.
- Describe the procedure for setting up a press tool on a press.
- List the various movements and forces in the blanking of a component.
- Measure a blanked component and examine the cut edge.
- Determine the relationship between component size to punch and die sizes.
- List and describe the typical wear areas in a press tool and comment on the die life.
- Describe die life, die land, die relief and sharpening.
- List safety precautions to be adhered to when using a press tool.

1.0 Calculating Punch And Die Clearance In Relation To Material Type And Thickness

Key Learning Points

Calculations: punch and die clearance in relation to material type and thickness transposition of formulae.

1.1 Calculations: Punch And Die Clearance In Relation To Material Type And Thickness Transposition Of Formulae

It is important that the correct clearance is used between the punch and die. When making a blanking tool, the die is made to the required size and the clearance is subtracted from the punch. When piercing, the punch is made to the required size and the clearance is added to the die. The clearance between the punch and die will vary depending on the material being blanked and the thickness of the material. For example for mild steel, the recommended clearance is 5-7% of the thickness of the material being blanked, for copper it is 3-4% and for aluminium 2%.

Example 1:

To punch a Ø15mm blank from 1mm thick copper. The recommended clearance is 4%.

The diameter of the punch is calculated as follows:

Diameter of die = diameter of blank = 15mm

Clearance per side = 4% of 1mm = 0.04mm

Clearance on the diameter = 0.04 x 2 = 0.08mm

Therefore the Punch diameter = 15 – 0.08 = 14.92mm

Example 2:

To punch a Ø15mm hole in 1mm thick copper. The recommended clearance is 4%.

The diameter of the punch is calculated as follows:

Diameter of punch = diameter of hole = 15mm

Clearance per side = 4% of 1mm = 0.04mm

Clearance on the diameter = 0.04 x 2 = 0.08mm

Therefore the Die diameter = 15 + 0.08 = 15.08mm

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 16, *Presswork,* sec. 16.2, *Press-tool design*, p. 270. ISBN-13: 9780750660730

2.0 Precision Machining The Cutting Area On The Punch And Die

Key Learning Points

Analysis of the variety of approaches to machining due to steel hardness/tolerances. Precision jig boring and reaming. Production and precision machining of the punch and die.

2.1 Analysis Of The Variety Of Approaches To Machining Due To Steel Hardness/Tolerances

Tool steel is used for the punch and die components. In its annealed state it can be milled or turned, ensuring to leave a grinding allowance. Heat treatment is then used to harden the tool steel. This tool steel alloy contains other elements such as carbon, manganese, tungsten and chromium. It is an excellent material for punches and dies and will not crack or distort when it is being heat treated. In order to achieve the required tolerance the components are ground to size.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 13, *Materials*, sec. 13.5, *Heat treatment*, p. 217.
ISBN-13: 9780750660730

2.2 Precision Jig Boring And Reaming

When holes need to be machined to a high degree of accuracy and surface finish, reamers and jig boring tools need to be used. For smaller holes reamers can be used, but for larger holes or holes of non-standard size, the jig boring tool needs to be used. When using the *Reamer*, the hole needs to be pre-drilled. The recommended amount of stock that a reamer should remove is 0.3 to 0.5mm depending on the size or the hole being reamed. The *Boring Head* has an adjustable boring bar, which needs to be set prior to machining. The boring head is fed into the workpiece using the automatic feed in the machine head. The bore can be checked with a telescopic gauge and micrometer. It is important to recheck the bore as errors easily can be made when using these gauges. If the holes to be bored are dimensioned from a central feature such as a hole, then this hole should be used as the datum. The spindle can be positioned accurately over the centre of this hole by using a dial indicator.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 8, *Drilling*, pp. 133, 153.
ISBN-13: 9780750660730

2.3 Production And Precision Machining Of The Punch And Die

When a die or a punch needs to be manufactured, it should be machined from tool steel using the mill or lathe. It is important that an adequate grinding allowance is left on the components prior to heat treatment, which is used to increase hardness. The components are then ground to the required accuracy and surface finish.

3.0 Procedure For Setting Up A Press Tool On A Press

Key Learning Points

Press tool set up procedure.

3.1 Press tool set up procedure

The press tool is assembled and placed on the bed of the press. The base of the press tool is clamped onto the bed. The top platen is then wound down and clamped onto the spigot, which is attached to the top plate of the press tool. The press stroke and feed are then adjusted prior to running the tool.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 16, *Presswork*, sec. 16.2, *Presswork*, p. 264.
ISBN-13: 9780750660730

4.0 Movements And Forces In The Blanking Of A Component

Key Learning Points

Shear force: area being pierced x material thickness, tensile strength.

4.1 Shear Force: Area Being Pierced X Material Thickness, Tensile Strength

The maximum force required to punch the material depends on the area of the edge to be sheared and the shear strength of the material. The formula used to calculate the maximum punch force necessary to blank the metal strip is as follows:

Blanking Force = Ultimate shear stress of the metal x shearing area

Ref: Timings, R.L. 1998, *Manufacturing technology*, vol. 1, 3rd edn, Pearson Education Limited, chapter 1, *Alteration of shape*, ex. 1.1, p. 50.
ISBN-13: 9780582356931

5.0 Measuring A Blanked Component And Examining The Cut Edge

Key Learning Points

Measure a blanked component and examine the cut edge.

5.1 Measure A Blanked Component And Examine The Cut Edge

The blank or a hole will always have a taper but this needs to be kept to a minimum. Upon inspection of the blank it will be found that the size of the die will be the same size as the blank.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 16, *Presswork; Press-tool design*, p. 269.
ISBN-13: 9780750660730

6.0 The Relationship Between Component Size To Punch And Die Sizes

Key Learning Points

Relationship of component size to punch and die sizes.

6.1 Relationship Of Component Size To Punch And Die Sizes

Upon inspection of the blank it will be found that (i) the size of the punch will be the same size as the hole it produced and (ii) the size of the die will be the same size as the blank.

7.0 Describing The Typical Wear Areas In A Press Tool And Comment On The Die Life

Key Learning Points

Wear areas in press tools, effect of friction.

7.1 Wear Areas In Press Tools, Effect Of Friction

The high forces and friction involved in presswork will eventually lead to wear on the sharp corners of the punch and die. These edges can be sharpened by grinding the bottom surface of the punch and the top surface of the die.

8.0 Die Life, Die Land, Die Relief And Sharpening

Key Learning Points

Press tool terminology as in die land, die relief, die life. Methods of re-sharpening a press tool.

8.1 Press Tool Terminology As In Die Land, Die Relief, Die Life

Die life is the time it takes for the sharp corner of the die to wear. The die land is the vertical land of the die, which cuts and guides the blank. The die relief or clearance beneath the vertical die walls prevents the blank from jamming in the die.

When the sharp edges of the die or punch become worn, they can be re-sharpened by grinding.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 16, *Presswork; Press-tool design*, p. 269.
ISBN-13: 9780750660730

8.2 Method Of Re-Sharpening A Press Tool

The press tool can be re-sharpened by grinding the bottom face of the punch and grinding the top surface of the die.

9.0 Safety Precautions To Be Adhered To When Using A Press Tool

Key Learning Points

Manual handling and safety procedures in using press tools and press tool presses. Professional approach to procedures.

9.1 Manual Handling And Safety Procedures In Using Press Tools And Press Tool Presses

The *Press* used to drive the *press tool* is a powerful machine and potentially very dangerous. High forces involved in the cutting or forming of metal can result in serious injury if the operator is too close to any part of the press tool or press during operation. Therefore the press should never be operated without the guards being in place. Protective clothing and eye protection should always be worn.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 16, *Presswork; Safety*, p. 268.
ISBN-13: 9780750660730

9.2 Professional Approach To Procedures

In industry there are many procedural requirements that need to be adhered to, especially safety procedures. In relation to Presswork, procedures have to be followed both when setting up and using the press tool. It is very important to put the power switch in the 'off' position when setting up the press tool and ensure that all guards are in place prior to operating the tool.

Setting up and running the press tool should only be performed out by a qualified person.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 1, *Safe practices*, sec. 1.9, *PUWER*, p. 6.
ISBN-13: 9780750660730

Summary

Calculating punch and die clearance in relation to material type and thickness: It is important that the correct clearance is used between the punch and die. When making a blanking tool, the die is made to the required size and the clearance is subtracted from the punch. When piercing, the punch is made to the required size and the clearance is added to the die. The clearance between the punch and die will vary depending on the material being blanked and the thickness of the material. For example for mild steel, the recommended clearance is 5-7% of the thickness of the material being blanked, for copper it is 3% and for aluminium 2%.

Precision machining the cutting area on the punch and die: When holes need to be machined to a high degree of accuracy and surface finish, reamers and jig boring tools need to be used. For smaller holes reamers can be used, but for larger holes or holes of non-standard size, the jig boring tool needs to be used.

When a die or a punch needs to be manufactured, it should be machined from tool steel using the mill or lathe. It is important that an adequate grinding allowance is left on the components prior to heat treatment, which is used to increase hardness. The components are then ground to the required accuracy and surface finish.

Procedure for setting up a press tool on a press: The press tool is assembled and placed on the bed of the press. The base of the press tool is clamped onto the bed. The top platen is then wound down and clamped onto the spigot, which is attached to the top plate of the press tool. The press stroke and feed are then adjusted prior to running the tool.

Movements and forces in the blanking of a component: The maximum force required to punch the material depends on the area of the edge to be sheared and the shear strength of the material.

Measuring a blanked component and examining the cut edge: The blank or a hole will always have a taper but this needs to be kept to a minimum. Upon inspection of the blank it will be found that the size of the die will be the same size as the blank.

The relationship between component size to punch and die sizes: Upon inspection of the blank it will be found that (i) the size of the punch will be the same size as the hole it produced and (ii) the size of the die will be the same size as the blank.

Describing the typical wear areas in a press tool and comment on the die life: The high forces and friction involved in presswork will eventually lead to wear on the sharp corners of the punch and die. These edges can be sharpened by grinding the bottom surface of the punch and the top surface of the die.

Die life, die land, die relief and sharpening: Die life is the time it takes for the sharp corner of the die to wear. The die land is the vertical land of the die, which cuts and guides the blank. The die relief or clearance beneath the vertical die walls prevents the blank from jamming in the die.

Safety precautions to be adhered to when using a press tool: The *Press* used to drive the *press tool* is a powerful machine and potentially very dangerous. High forces involved in the cutting or forming of metal can result in serious injury if the operator is too close to any part of the press tool or press during operation. Therefore the press should never be operated without the guards being in place. Protective clothing and eye protection should always be worn.

Suggested Exercises

1. Calculate the diameter of a Punch for punching out a Ø12mm blank from a 1.5mm thick copper strip.
2. Ream a Ø10mm hole into a mild steel plate, ensuring to leave adequate material for reaming.
3. Calculate the spindle speeds for drilling and reaming a Ø10mm hole into a mild steel plate.
4. Draw a free hand sketch of a section through a press tool die plate and label the die land and die relief.
5. How is a punch sharpened?

Questions

1. What is the recommended clearance between the punch and die for the following materials: (i) Mild Steel and (ii) Copper and (iii) Aluminium.
2. Calculate the diameter of a Punch for punching out a Ø14mm blank from a 1.0mm thick copper strip.
3. Why is Tool Steel a good material for a Punch?
4. In press tool terminology, what is Die Life?
5. How are the Punch and the Die re-sharpened when they become worn?

Answers

1. (i) The recommended clearance for mild steel is 5-7% of the thickness of the material being blanked, for (ii) copper it is 3-4% and for (iii) aluminium 2%.
2. To punch a Ø16mm blank from 1mm thick copper. The recommended clearance is 4%. The diameter of the punch is calculated as follows:
   Diameter of die = diameter of blank = 16mm
   Clearance per side = 4% of 1mm = 0.04mm
   Clearance on the diameter = 0.04 x 2 = 0.08mm
   Therefore the Punch diameter = 16 – 0.08 = 15.92mm
3. Tool steel can be machined in its softer annealed state and can then be heat treated to harden it for use as a Punch. It is an excellent material for punches and dies and will not crack or distort when it is being heat treated.
4. Die life is the time it takes for the sharp corner of the die to wear. The die land is the vertical land of the die, which cuts and guides the blank.
5. The press tool components can be re-sharpened by grinding the bottom face of the punch and grinding the top surface of the die.

Recommended Additional Resources

Reference Books

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

ISBN-13: 9780750660730

Bird, John 2005, *Basic engineering mathematics*, 4th edn, Elsevier Science & Technology.

ISBN-13: 9780750665759

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

ISBN-13: 9780582356931