| Trade of Toolmaking |  |
| ---: | :--- |
| Module 3: | Milling |
| Unit 2: | Aligning, Machine Head, <br> Table \& Vice |
|  | Phase 2 |

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## Document Release History

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## Unit Objective

On completion of this unit you will be able to setup and use a dial test indicator for aligning the milling machine head, table and the vice. This unit also identifies common work holding methods.

## Introduction

Module three of this course covers milling. This is the second unit in module three and introduces the techniques associated with aligning or clocking the head of the vertical milling machine, which needs to be perpendicular with the table. When the head is aligned and square with the table, the vice is then aligned so that the jaws are parallel to the X axis of the table. The vice is the most common method of holding the workpiece while it is being machined. Other work holding devices that are used are V-blocks, Angle Plates, Clamps, Dividing Head and special fixtures.


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

- Correctly setup and use a dial test indicator.
- Setup and align/clock the machine head.
- Setup and align/clock machine table.
- Setup and align machine vise.
- Identify common work holding arrangements.


### 1.0 Setting Up And Using A Dial Test Indicator

## Key Learning Points

Setup of the dial test indicator, use of magnetic bases. Operation of dial gauge and universal stand. Reading of the graduations of a dial test indicator, zero set the dial indicator. Errors associated with using dial test indicators

### 1.1 Setup Of The Dial Test Indicator, Use Of Magnetic Bases

When aligning or clocking the head or the vice of the vertical milling machine, attach a dial indicator to the spindle. There are two types of dial indicator, a plunger type and a lever type. If the plunger type dial indicator is being used to align the head then it should be free to rotate about the spindle, while the plunger is in contact with the table. When the vice is being aligned, a dial indicator with a magnetic base attachment is positioned onto the front of the column. The plunger is positioned against the fixed jaw of the vice or against a parallel that can be clamped into the vice.

Ref: Black, Bruce J 2004, Workshop processes, practices and materials, $3^{\text {rd }}$ edn, Elsevier Science \& Technology, chapter 6, Measuring equipment; Dial indicators, p. 108.
ISBN-13: 9780750660730

### 1.2 Operation Of Dial Gauge And Universal Stand

When the first reading is taken, set the dial to zero and the difference can be calculated when the dial indicator is moved onto a new position. The device being aligned is adjusted until the dial reads zero along its length.
Ref: Black, Bruce J 2004, Workshop processes, practices and materials, $3^{\text {rd }}$ edn, Elsevier Science \& Technology, chapter 6, Measuring equipment; Dial indicators, p. 108.
ISBN-13: 9780750660730

### 1.3 Reading Of The Graduations Of A Dial Test Indicator, Zero Set The Dial Indicator

A typical dial indicator allows the plunger to move up to 20 mm and is graduated in 0.01 mm .
Ref: Black, Bruce J 2004, Workshop processes, practices and materials, $3^{\text {rd }}$ edn, Elsevier Science \& Technology, chapter 6, Measuring equipment; Dial indicators, p. 108.
ISBN-13: 9780750660730

### 1.4 Errors Associated With Using Dial Test Indicators

It is important that the dial indicator plunger is positioned square with the table or the jaw of the vice or the parallel; otherwise the reading will not be true.

### 2.0 Setting Up And Aligning The Machine Head

## Key Learning Points

Alignment of the machine head perpendicular to X and Y axis using a dial test indicator. Tightening of clamping bolts.

### 2.1 Alignment Of The Machine Head Perpendicular To X And Y Axis Using A Dial Test Indicator

When aligning the machine head loosen the four bolts, but keep them lightly tightened. When the dial indicator is reading zero in both positions, tighten the bolts again but not fully. Again check the alignment again, as the head can move when the bolts are tightened. Finally lock the four bolts.

### 2.2 Tightening Of Clamping Bolts

The procedure for tightening the bolts in the head are as follows, Tighten the first bolt, then tighten the bolt diagonal to it and then the final two bolts. Finally lock all bolts again.

### 3.0 Setting Up And Aligning The Table

## Key Learning Points

Alignment of table.

### 3.1 Alignment Of Table

The table of a typical vertical milling machine is aligned at the factory and cannot be adjusted by the operator. The table of the universal milling machine can be rotated for machining at the required angle, but the table will need to be aligned afterwards. The table is aligned using a dial indicator.

### 4.0 Setting Up And Aligning The Vice

## Key Learning Points

Vice setup, clamping devices/arrangements. Align vice parallel to X axis using a dial test indicator. Align the vice to the Y axis to ensure the vice is seated properly.

### 4.1 Vice Setup, Clamping Devices/Arrangements

Prior to setting up the vise on the table, ensure that both the table and the underside of the vise are clean. Position the vise with the jaws parallel to the X axis if the table. Fit and tighten the tee bolts to secure the vise in position. A dial indicator with a magnetic base should be attached the front column. Insert a parallel between the jaws of the vice and tighten, ensuring that it protrudes above the jaws, so that it can make contact with the dial indicator.

### 4.2 Align Vice Parallel To X Axis Using A Dial Test Indicator

Set the dial indicator plunger square against the back of the parallel and set to zero. Traverse the vise back and forth and tap the vise with a soft headed mallet until the dial indicator is reading the same at both ends of the fixed jaw. Tighten the tee bolts and check the vise alignment again.

### 4.3 Align The Vice To The Y Axis To Ensure The Vice Is Seated Properly

To align the vice so that it is parallel with the cross-feed (Y axis), position the vice with the jaws approximately parallel to the Y axis. Fit the tee bolts and set up the dial indicator as explained above. Traverse the feed back and forth and adjust the vice until the reading is the same in both positions of the fixed jaw. Tighten the tee bolts and check the vise alignment again.

### 5.0 Identifying Work Holding Arrangements

## Key Learning Points

Safe operation of machine and attachments. Work holding devices, examples of simple jigs and fixtures. Lifting/set up procedures (safe removal and fitting of vices etc.). Metric system: millimetres - subdivisions of millimetres.

### 5.1 Safe Operation Of Machine And Attachments

When using a milling machine it is important to observe the following:

- Wear safety goggles and suitable clothing.
- Keep the machine and surrounding area clean and tidy.
- Use a brush to remove swarf from the machine.
- Use correct tools and equipment.
- Store all cutters in a safe place.
- Use correct lifting methods.
- Switch off machine when not in use.


### 5.1 Work Holding Devices, Examples Of Simple Jigs And Fixtures

The vice is the primary method of holding a workpiece when milling. Other devices can be used such as; Angle Plate, which can be used to hold large plates and when machining surfaces at right angles to each other, Clamps, irregular shaped work can be clamped directly onto the table and machined in place, Vee Block, used in combination with a clamp and can be used to hold and machine cylindrical workpieces, Dividing Head, used to machine gears, circular array of holes etc. Jigs and fixtures can also be manufactured for work holding, but these are normally used for machining high volume products.
Ref: Black, Bruce J 2004, Workshop processes, practices and materials, $3^{\text {rd }}$ edn, Elsevier Science \& Technology, chapter 11, Milling, sec. 11.5, Workholding, p. 184.
ISBN-13: 9780750660730

### 5.2 Lifting/Set Up Procedures (Safe Removal And Fitting Of Vices Etc.)

When lifting the vice, it is important to keep your back straight and bend your knees when lifting or lowering the chuck. Ensure that the floor space around the lathe is free from debris, oil or coolant. Vices, rotary tables and dividing heads are heavy, if you have difficulty lifting or fitting this equipment, ask for help.
Ref: Black, Bruce J 2004, Workshop processes, practices and materials, $3^{\text {rd }}$ edn, Elsevier Science \& Technology, chapter 19, Moving loads, p. 305.
ISBN-13: 9780750660730

### 5.3 Metric System: Millimetres - Subdivisions Of Millimetres

The table leadscrew has a pitch of 5 mm , therefore the table will move 5 mm for one complete rotation of the hand wheel. The hand wheel dial is graduated into subdivisions of 0.2 mm , which are marked in 0.2 mm increments. Each of these main divisions is subdivided in ten divisions, where each division is equal to 0.02 mm .

## Summary

Setting up and using a dial test indicator: When aligning or clocking the head of the vertical milling machine, attach a dial indicator to the spindle. The dial indicator should be free to rotate about the spindle, while the plunger is in contact with the table. When the vice is being aligned, a dial indicator with a magnetic base attachment is positioned onto the front of the column. The plunger is positioned against the fixed jaw of the vice or against a parallel that can be clamped into the vice.
It is important that the dial indicator plunger is positioned square with the table or the jaw of the vice, otherwise the reading will not be true. When the first reading is taken, set the dial to zero and the difference can be calculated when the dial indicator is moved onto a new position. A typical dial indicator allows the plunger to move up to 20 mm and is graduated in 0.01 mm .
Setting up and aligning the machine head: When aligning the machine head loosen the four bolts, but keep them lightly tightened. When the dial indicator is reading zero in both positions, tighten the bolts again but not fully. Again check the alignment again, as the head can move when the bolts are tightened. Finally lock the first bolt, then lock the bolt diagonal to it and then the final two bolts.

Setting up and aligning machine table: The table of a typical vertical milling machine is aligned at the factory and cannot be adjusted by the operator. The table of the universal milling machine can be rotated for machining at the required angle, but the table will need to be aligned afterwards. The table is aligned using a dial indicator.
Setting up and aligning machine vice: Prior to setting up the vice on the table, ensure that both the table and the underside of the vice are clean. Position the vice with the jaws parallel to the X axis if the table. Fit and tighten tee bolts to secure the vice in position. A dial indicator with a magnetic base should be attached the front column. Set the dial indicator plunger square against the fixed jaw of the vice and set to zero. Traverse the vice back and forth and tap the vice with a soft headed mallet until the dial indicator is reading the same at both ends of the fixed jaw. Tighten the tee bolts and check the vice alignment again.
Identifying work holding arrangements: The vice is the primary method of holding a workpiece when milling. Other devices can be used such as; Angle Plate, which can be used to hold large plates and when machining surfaces at right angles to each other, Clamps, irregular shaped work can be clamped directly onto the table and machined in place, Vee Block, used in combination with a clamp and can be used to hold and machine cylindrical workpieces, Dividing Head, used to machine gears, circular array of holes etc.

## Suggested Exercises

1. What are the two types of dial indicator used to align the head and the vice.
2. Explain how to align the head of a vertical milling machine.
3. Using a dial indicator, align the vice parallel to the X axis.
4. List three other work holding devices.
5. What safety procedures should you take when removing the vice?
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## Questions

1. What is the purpose of the dial indicator and list the two types?
2. Why is it important to position the plunger of the dial indicator square or perpendicular to the table or vice being aligned.
3. Explain how the dial indicator is setup to align the vice of a milling machine.
4. How is a vice aligned along the Y axis?
5. What much travel does a plunger have on a typical dial indicator and what is the measuring accuracy of the graduations.
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## Answers

1. The dial indicator is used to align or clock the head or the vice of the vertical milling machine. There are two types of dial indicator, (i) a plunger type and a (ii) lever type.
2. The plunger of the dial indicator should be positioned square with the table or the jaw of the vice, otherwise the reading will not be true.
3. When the vice is being aligned, a dial indicator with a magnetic base attachment is positioned onto the front of the column. The plunger is positioned against the fixed jaw of the vice or against a parallel that can be clamped into the vice.
4. To align the vice so that it is parallel with the cross-feed (Y axis), position the vice with the jaws approximately parallel to the Y axis. Fit the tee bolts and set up the dial indicator as explained above. Traverse the feed back and forth and adjust the vice until the reading is the same in both positions of the fixed jaw. Tighten the tee bolts and check the vice alignment again
5. A typical dial indicator allows the plunger to move up to 20 mm and is graduated in 0.01 mm .

## Recommended Additional Resources

## Reference Books

Black, Bruce J 2004, Workshop processes, practices and materials, $3^{\text {rd }}$ edn, Elsevier Science \& Technology.
ISBN-13: 9780750660730
Simmons, Colin H \& Maguire, Dennis E 2004, Manual of engineering drawing, ${ }^{\text {nd }}$ edn, Elsevier Science \& Technology.

ISBN-13: 9780750651202
Bird, John 2005, Basic engineering mathematics, $4^{\text {th }}$ edn, Elsevier Science \& Technology. ISBN-13: 9780750665759

