

Trade of Toolmaking	
Module 3:	Milling
Unit 1:	Operating Machine Controls
	Phase 2

Published by



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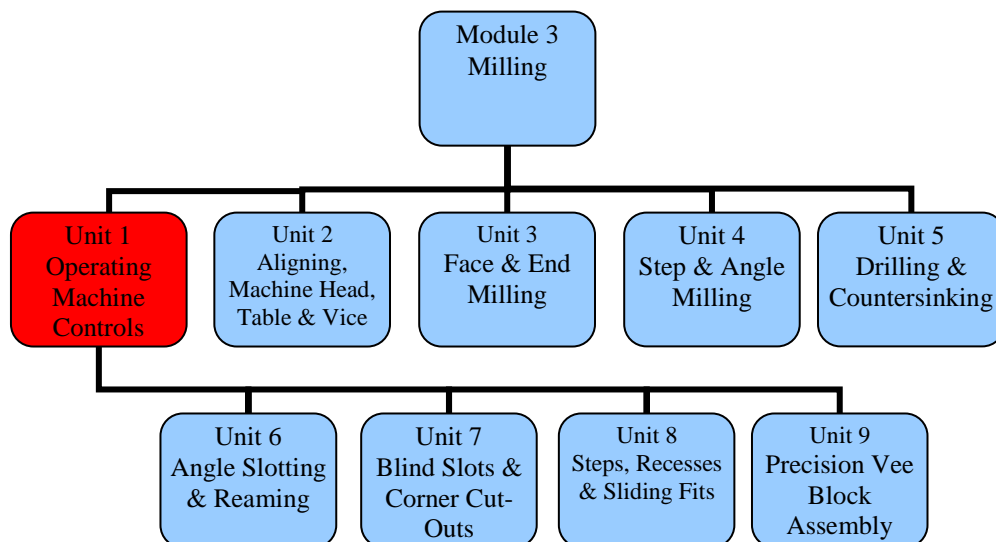
Unit Objective

On completion of this unit you will be able to operate the milling machine, describe its functions and features, identify and safely operate all leavers and controls.

Introduction

Module three of this course covers milling. This is the first unit in module three and introduces the techniques associated with operating a milling machine. The milling machine produces flat surfaces that can be parallel, perpendicular or at an angle to the table. It can be used to machine slots and holes. The workpiece to be machined can be held in a vice, held on an angle plate, clamped onto the table or held in a dividing head or rotary table.

The milling machine is suited to both low and high volume production. There are two main types of milling machine, the vertical and the horizontal milling machine. The machine that is being discussed in this unit is the vertical milling machine. The vertical milling machine is mainly used in Toolrooms, while the horizontal milling machine is mainly used in higher volume production.



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

- Identify the parts of the milling machine.
- Describe the function of the main parts of the vertical milling machine.
- Identify and safely operate all leavers and controls i.e. isolation switch, emergency stop and emergency stop.
- Move the table using graduated leadscrews in each of the axes.

1.0 Identifying The Parts Of The Milling Machine

Key Learning Points

Identification of levers and controls: spindle speed selection, start/stop switches, automatic feed controls, coolant isolation

1.1 Identification Of Levers And Controls: Spindle Speed Selection, Start/Stop Switches, Automatic Feed Controls, Coolant Isolation

The vertical and horizontal milling machine is made up of various parts, such as: the spindle, speed changing levers, spindle hand lever and the hand wheel, which are all supported above the table by the column. The table, which consists of a flat grooved bed, table traverse hand wheels, the leadscrew and if fitted the automatic table feed. Below the table is the Cross Feed, which consists of the cross feed handle and leadscrew. Beneath the cross feed is the Vertical feed hand wheel. The main difference between the vertical and horizontal milling machines are that the spindle is vertical in the vertical milling machine and is positioned horizontally in the horizontal milling machine. The vertical milling is the most common milling machine used by the Toolmaker.

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

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2.0 The Functions Of The Main Parts Of The Vertical Milling Machine

Key Learning Points

Describe the function of the main parts of the vertical milling machine

2.1 Describe The Function Of The Main Parts Of The Vertical Milling Machine

The Spindle, which is located above the table rotates about the vertical axis and can be moved up and down either manually or automatically. The spindle can also be tilted for milling or drilling at an angle. The milling cutter or drill is held in the spindle, which rotates about the vertical (Z) axis.

The Table is used support the workpiece and can be moved along the X (left or right), Y (back or forth) and Z (up or down) axes. The workpiece can be held in a vice or can be clamped directly onto the table, the workpiece can also be held in other devices such as the dividing head, rotary table or a fixture. When milling, the cutter rotates in the spindle, while the table, which holds the workpiece, is moved either in the X axis by the table traverse hand wheel or in the Y axis by the cross feed hand wheel. The workpiece is fed in the Z direction by the vertical feed hand wheel to move the workpiece towards or away from the milling cutter.

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

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3.0 Identifying And Safely Operating All Leavers And Controls

Key Learning Points

Characteristics and operation of the vertical milling machine. Emergency shut down procedure and machine isolation. Safe operation of machine and organisation of surrounding areas. Job planning, tool selection and setup.

3.1 Characteristics And Operation Of The Vertical Milling Machine

When changing the cutter in a vertical milling machine, it is normally done by unscrewing the draw bar at the top of the spindle with a ring spanner. It is important to remove the spanner from the draw bar when the new cutter has been tightened in place.

The spindle hand lever feed is used to feed a drill into the workpiece. When machining with the milling cutter, it is important to lock the spindle in place with the locking knob, in order to prevent the spindle moving along the Z axis.

When milling a workpiece, say for example in the X direction, it is important to lock the table in order to prevent the table accidentally moving the Y direction, which may damage the workpiece or the cutter and cause injury

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3.2 Emergency Shut Down Procedure And Machine Isolation

Switch off the machine when not in use and in the case of an emergency press the red stop button to stop the machine.

3.3 Safe Operation Of Machine And Organisation Of Surrounding Areas

When using the milling machine it is important to wear eye protection, suitable clothing, use a brush to remove swarf and keep the machine and surrounding area tidy.

3.4 Job Planning, Tool Selection And Setup

Job planning is important prior to starting any task. The drawing should first be studied and understood. The drawing can initially be used to calculate the material requirement for the component to be manufactured. The workpiece needs to be cut from bar stock by using the bandsaw. The sequence of operations should be planned so as to minimise the number of setups in the vice.

4.0 Moving The Table Using Graduated Leadscrews In Each Axes

Key Learning Points

Knowledge and understanding of axes designation, movements of the machine. Use of leadscrew dials, labelling of machine axes. Digital readout and use of digital readout to establish a datum.

4.1 Knowledge And Understanding Of Axes Designation, Movements Of The Machine

The axes are designated as follows: The axis to the left of the workpiece is designated as -X and the axis to the right is +X. The axis from the workpiece towards the operator is -Y and back is +Y. The axis upwards from the workpiece is +Z and downwards is -Z.

4.2 Use Of Leadscrew Dials, Labelling Of Machine Axes

When operating a milling machine, it is important to be familiar with the hand wheels and their dials, which control the leadscrews and thus the table movements. Clockwise rotation of the hand wheel will cause the table to move away from you and anti-clockwise rotation will cause the table to move towards you. Each of the handles are provided with dials, that provide the operator a means of controlling the table movements. The dials are graduated in metric and one full revolution of the dial will move the table 5mm. Each division on the dial is 0.1mm, therefore to move the table 1.1mm, the dial is moved 11 divisions.

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4.3 Digital Readout And Use Of Digital Readout To Establish A Datum

A digital readout, if fitted, is much easier to use than the dials. When a datum has been established at the edge of a workpiece, then the digital readout can be set to zero on the X, Y and Z axis. The workpiece can then be moved to the required position as specified on the drawing. The digital readout works by reading the signals generated by an encoder, which is installed along the machine axis and keeps track of the workpiece position.

Summary

Identify the parts of the milling machine: The vertical milling machine is made up of various parts, such as: the spindle, speed changing levers, spindle hand lever and the hand wheel, which are all supported above the table by the column. The table, which consists of a flat grooved bed, table traverse hand wheels, the leadscrew and if fitted the automatic table feed. Below the table is the Cross Feed, which consists of the cross feed handle and leadscrew. Beneath the cross feed is the Vertical feed hand wheel.

The functions of the main parts of the milling machine: The Spindle, which is located above the table rotates about the vertical axis and can be moved up and down either manually or automatically. The spindle can also be tilted for milling or drilling at an angle. The milling cutter or drill is held in the spindle, which rotates about the vertical (Z) axis.

The Table is used support the workpiece and can be moved along the X (left or right), Y (back or forth) and Z (up or down) axes. The workpiece can be held in a vice or can be clamped directly onto the table, the workpiece can also be held in other devices such as the dividing head, rotary table or a fixture. When milling, the cutter rotates in the spindle, while the table, which holds the workpiece, is moved either in the X axis by the table traverse hand wheel or in the Y axis by the cross feed hand wheel. The workpiece is fed in the Z direction by the vertical feed hand wheel to move the workpiece towards or away from the milling cutter.

Identifying and safety operating all leavers and controls: When using the milling machine it is important to wear eye protection, suitable clothing, use a brush to remove swarf and keep the machine and surrounding area tidy. Switch off the machine when not in use and in the case of an emergency press the red stop button to stop the machine.

When changing the cutter in a vertical milling machine, it is normally done by unscrewing the draw bar at the top of the spindle with a ring spanner. It is important to remove the spanner from the draw bar when the new cutter has been tightened in place.

The spindle hand lever feed is used to feed a drill into the workpiece. When machining with the milling cutter, it is important to lock the spindle in place with the locking knob, in order to prevent the spindle moving along the Z axis.

When milling a workpiece, say for example in the X direction, it is important to lock the table in order to prevent the table accidentally moving the Y direction, which may damage the workpiece or the cutter and cause injury.

Moving the table using graduated leadscrews in each of the axes: When operating a milling machine, it is important to be familiar with the hand wheels and their dials, which control the table movements. Clockwise rotation of the hand wheel will cause the table to move away from you and anti-clockwise rotation will cause the table to move towards you. Each of the handles are provided with dials, that provide the operator a means or controlling the table movements. Digital readouts, if fitted, are much easier to use than the dials. When a datum has been established at the edge of a workpiece, then the digital readout can be set to zero on the X, Y and Z axis. The workpiece can then be moved to the required position as specified on the drawing. The digital readout works by reading the signals generated by an encoder, which is installed along the machine axis and keeps track of the workpiece position.

Suggested Exercises

1. Sketch and name the main parts of a milling machine.
2. Prepare a free hand isometric sketch of the table showing the X, Y and Z axes.
3. Explain how to insert and remove an end mill from the spindle.
4. If the pitch on the leadscrew is 5mm, what distance will the table move when the hand wheel is rotated by one full revolution.
5. What safety precaution should you take when using a milling machine.

Questions

1. What are the two main types of milling machine.
2. What is the main difference between the vertical and horizontal milling machines?
3. Explain axis designation on a vertical milling machine.
4. What is the function of the Spindle on the vertical milling machine?
5. What is the function of the Table on a milling machine?

Answers

1. The vertical and horizontal milling machine.
2. The main difference between the vertical and horizontal milling machines are that the spindle is vertical in the vertical milling machine and is positioned horizontally in the horizontal milling machine. The vertical milling is the most common milling machine used in the workshop.
3. The axes are designated as follows: The axis to the left of the workpiece is designated as $-X$ and the axis to the right is $+X$. The axis from the workpiece towards the operator is $-Y$ and back is $+Y$. The axis upwards from the workpiece is $+Z$ and downwards is $-Z$.
4. The milling cutter is held in the Spindle of the milling machine. The Spindle rotates about the vertical (Z) axis and drives the cutter during the milling operation. The Spindle can also be used to move a drill up and down either manually or automatically. The spindle can be tilted for milling or drilling at the required angle, by rotating the head of the machine.
5. The Table supports the workpiece during the milling or drilling operations. The table can be moved along the X (left or right), Y (back or forth) and Z (up or down) axes. The workpiece is either held in a vice or can be clamped directly onto the table, the workpiece can also be held in other devices such as the dividing head, rotary table or a fixture, which need to be clamped to the table.

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

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

ISBN-13: 9780750665759