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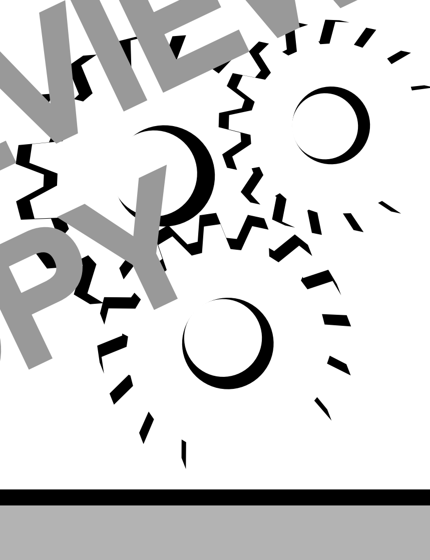
BASIC MILLING PROCEDURES

Lesson One

Using the Horizontal Milling Machine



TPC Training Systems

32601

Lesson

1 Using the Horizontal Milling Machine

TOPICS

Milling Machine Parts and Their Functions
Vertical Milling Attachment
Machine Orientation
Milling Speed Selection
Milling Feed Selection
Depth of Cut
Lubricants and Coolants
Mounting the Workpiece
Using V-Blocks
The Milling Machine Vise
Aligning the Vise on the Table
Installing Work in a Vise

OBJECTIVES

After studying this Lesson, you should be able to…

- Identify the major parts of a universal horizontal milling machine and their functions.
- Define the use of a vertical milling attachment.
- Compute the milling spindle speed and the machine table feed rate.
- Install and align a workpiece in a V-block.
- Install and align a workpiece in a milling machine vise.

KEY TECHNICAL TERMS

Column 1.03, Fig. 1-1 the main upright support member of a horizontal milling machine, which houses the drive motor and spindle controls

Knee 1.05, Fig. 1-1 the part of a horizontal milling machine that supports the saddle and machine table

Saddle 1.07, Fig. 1-1 the part of a horizontal milling machine that supports the machine table and is operated by the cross-feed handwheel

Overarm 1.10, Fig. 1-1 the part of a horizontal milling machine that provides support for arbors

Vertical milling attachment 1.13, Fig. 1-2 an attachment for a horizontal milling machine that changes the spindle rotation from horizontal to vertical

Cutter speed 1.24 the rate at which a cutter tooth passes over the workpiece surface

This Lesson presents the basic parts of a universal horizontal milling machine. Lesson One shows you where the basic controls are located and describes the functions of each of these controls. The use of the vertical milling attachment is also explained.

You will be given two formulas for finding the spindle speed and the machine-table feed rate. A typical milling example is given to illustrate how these speed and feed rates are computed.

Lesson One includes instructions for using the V-block and swivel vise in basic milling setups. The correct methods of installation and alignment for both of these basic holding devices are given. Finally, Lesson One presents a sample workpiece for you to set up on your milling machine.

Milling Machine Parts and Their Functions

1.01 The following four Lessons in this Unit involve milling operations on specific workpieces. These operations are done on a universal horizontal milling machine. Figure 1-1 shows the parts of a typical universal horizontal milling machine.

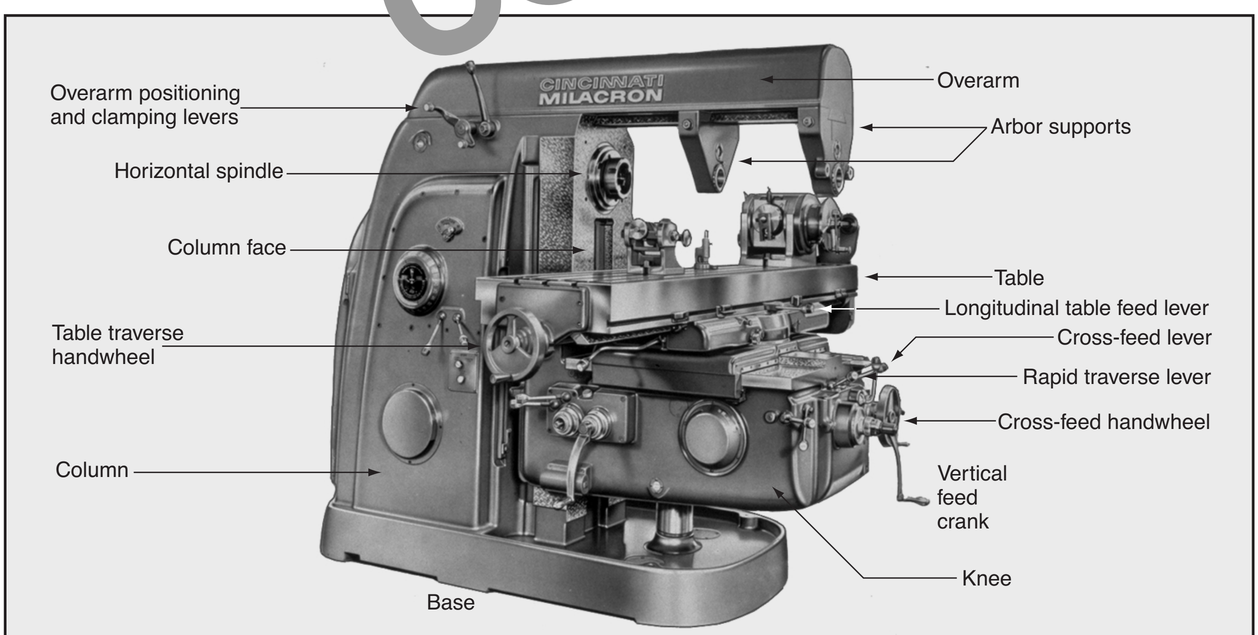
1.02 A universal horizontal milling machine is like a plain horizontal milling machine except it has a table swivel mounted on top of the saddle. The swivel allows you to rotate the table horizontally so it will feed past the cutter at different angles. You would use this feature to cut flutes in twist drills, for instance, or teeth on helical gears.

1.03 **Column.** The *column* is the main upright support member. It has an accurately machined face and ways. The column houses the drive motor and spindle speed controls.

1.04 The spindle nose projects out of the surface of the column face. This surface must be kept clean and lightly oiled. Use a good grade of way oil so the knee will move easily up and down on the column.

1.05 **Knee.** The *knee* supports the saddle and table, and moves them up or down the column. It has an accurately machined guide on its inside vertical surface. This guide slides along the machined face of the

Fig. 1-1. Universal horizontal milling machine



column as the knee is raised or lowered with the vertical hand crank. The knee provides vertical movement to a workpiece.

1.06 The top surface of the knee also has a machined guide on which the saddle can move toward or away from the column face. This in-and-out movement is called the cross feed. All of these machined sliding surfaces must be kept clean and lightly oiled.

1.07 **Saddle.** The *saddle* supports the work table. The saddle is moved toward and away from the column by turning the cross-feed handwheel. The top surface of the saddle has precision machined ways along which the table slides. The swivel is between the saddle and table.

1.08 **Table.** The milling machine table holds the workpiece and its fixtures. The table and work are moved from side to side by turning the table handwheel. T-slots in the top of the table are used to hold and clamp the workpiece. These slots should be cleaned thoroughly after each milling job.

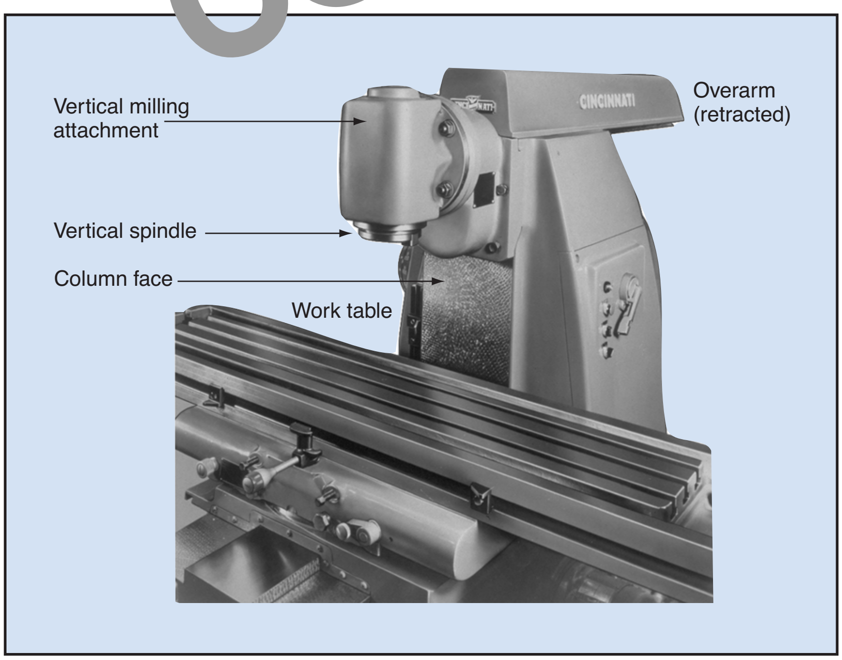
1.09 **Base.** The milling machine base is the foundation of the machine. The base is a rugged casting that serves as a collector for chips while the machine is operating.

1.10 **Overarm.** The *overarm* slides,in and out at the top of the column. This movement permits the overarm to support arbors of various lengths. To move the overarm, loosen the clamps and position the arbor support. Tighten the overarm clamps to lock the overarm in the correct position. Some milling jobs will require more than one arbor support. The inner arbor support bracket can be moved to any position along the underside of the overarm (Fig. 1-1). Then a second arbor support can be mounted on the bracket. A second arbor support provides greater rigidity to the arbor when you must mill heavier work or use unusual cutter mountings.

1.11 **Spindle.** The spindle holds the arbor, various adapters, chucks, and shank-type cutters. The spindle speed is controlled by a variable speed selector. This selector is usually found on the side of the column. The spindle can run in either a clockwise or counterclockwise direction. Direction of spindle rotation can be changed by shifting the directional control lever.

1.12 **Clamping levers**. The knee and saddle are held in their set positions by engaging clamping levers. After you move these parts to the desired position for a job, be sure you tighten the clamping levers before starting the milling machine. However, if you use any of the power feed devices, be sure that the

Fig. 1-2. Vertical milling attachment



clamping lever for the part to be power driven is fully disengaged.

Vertical Milling Attachment

1.13 The *vertical milling attachment* shown in Fig. 1-2 greatly increases the flexibility of a milling machine. This attachment is mounted on the spindle nose and bolted to the machined face of the column for support.

1.14 A system of gears in the vertical milling attachment changes the spindle rotation from horizontal to vertical. This vertical spindle position permits you to mill slots, dovetails, and other shapes on a horizontal milling machine.

1.15 The spindle in the vertical milling attachment can also be positioned at angles other than 90°. To do this, rotate the attachment housing on the axis of the horizontal spindle.

1.16 A collar on the vertical milling attachment is graduated in degrees to help you position the attachment at different angles. These angular settings are used to mill various bevels and slots. These different settings also allow you to drill holes at angles other than 90°.

1.17 Take care to follow the manufacturer's instructions when mounting, operating, and removing a vertical milling attachment. Study the construction features of the attachment in your machine shop. Be particularly careful not to damage the spindle nose when installing or removing the vertical milling attachment.

1.18 Do not allow the vertical milling attachment to scrape the machined surface on the column face. Clean out the threaded mounting holes in the column. Never force the bolts when tightening them. Forcing the bolts can cause misalignment of the vertical milling attachment and may damage the internal gearing.

Machine Orientation

1.19 Before starting any milling job in your shop, become fully acquainted with your machine. If possible, enlist the help of a co-worker who has used that particular machine.

1.20 Before installing work in the machine, move the various control levers that position the knee, saddle, and table. Start the machine and run the spindle through its complete range of available speeds before installing a cutter. This will give you a feel for the controls, which helps you when you set cutting speeds.

1.21 Work safely, using approved equipment. Always wear safety glasses. Never use your bare hands to clean off the work table. Milling work often produces very fine chips which can easily cut the skin. Many of the cutting fluids also contain irritants.

1.22 Always use a brush to sweep chips from the machine. Do not use air to clean the machine surfaces. It is dangerous and does not always do the job completely. Always leave the machine in good condition for the next operator.

Milling Speed Selection

1.23 The first thing you must determine in order to perform a job on a milling machine is the spindle speed. Spindle speed is always expressed in rpm. In order to compute spindle speed in rpm, you must first know certain other values. These other values are the cutter speed, expressed in sfpm (surface feet per minute), and the diameter of the cutter.

1.24 A milling cutter's speed is the rate at which a particular cutter tooth passes over the workpiece surface. *Cutter speed* is directly affected by the diameter of the cutter. For instance, a cutter with a 6 in. diameter has a higher sfpm than a cutter with a 4 in. diameter rotating at the same rpm.

1.25 You must refer to published tables to find the right cutter speed for the material you are working with. Table 1-1 on the following page shows cutter speeds for machining various materials with either high-speed steel or carbide-tipped cutters.

1.26 Once you have determined the correct cutter speed in sfpm for your workpiece material, you will next need to consider the diameter of the cutter. If you do not know the diameter of the cutter, measure it and write it down for use in the formula in paragraph 1.27.

1.27 Because the cutter diameter is expressed in inches and cutter speed is expressed in feet (sfpm), you must convert feet to inches to calculate the diameter's effect on the speed. You can do this by using a constant of 4. The constant of 4 is derived by dividing 12 (12 in. to the foot) by Pi (3.14) and rounding off the decimal. To find spindle speed, use the following formula:

$$\text{rpm} = \frac{\text{sfpm} \times 4}{D}$$

where rpm is the spindle speed

sfpm is the cutter speed

4 is a constant used to convert ft to in.

D is the cutter diameter.

1.28 For example, assume that you have a milling job on a workpiece of cast iron (medium). By referring to Table 1-1, you see that the recommended cutter speed is 50-60 sfpm. Use the lower figure of 50 in this formula. The job requires face milling using a cutter with a 4-in. diameter. You need to find the correct spindle speed. In this case:

$$\text{rpm} = \frac{50 \times 4}{4}$$

$$= 50 \text{ rpm for the spindle speed}$$

1.29 When you use published tables for selecting cutter speeds, remember to use the lower figure to start with. As you gain experience, you can increase the speed toward the maximum shown in the tables. However, starting at maximum cutter speeds can cause rapid cutter wear and tool chatter on the workpiece surface.

The Programmed Exercises on the next page will tell you how well you understand the material you have just read. Before starting the exercises, remove the REVEAL KEY from the back of your Book. Read the instructions printed on the Reveal Key. Follow these instructions as you work through the Programmed Exercises.

Table 1-1. Cutter speeds (surface feet per minute)

	High-speed steel		Carbide-tipped		
Material	**Rough**	**Finish**	**Rough**	**Finish**	**Coolant**
Cast iron	50 to 60	80 to 110	180 to [illegible]	350 to 400	Dry
Semi-steel	40 to 50	[illegible]5 to 90	[illegible]	250 to 300	Dry
Malleable iron	80 to 100	[illegible]	250 to 300	400 to 500	Soluble, sulfurized, or mineral oil
Cast steel	45 to 60	70 to 90	150 to 180	200 to 250	Soluble, sulfurized, mineral, or mineral lard oil
Copper	100 to 150	150 to 200	600	1000	Soluble, sulfurized, or mineral lard oil
Brass	200 to 300	200 to 300	600 to 1000	600 to 1000	Dry
Bronze	100 to 150	150 to 180	600	1000	Soluble, sulfurized, or mineral lard oil
Aluminum	400	700			Soluble, sulfurized oil, mineral oil and kerosene
Magnesium	600 to 800	1000 to 1500	1000 to 1500	1000 to 5000	Dry, kerosene, mineral lard oil
SAE steels					
1020 (coarse feed)	60 to 80	60 to 80	300	300	Soluble, sulfurized, mineral, or mineral lard oil
1020 (fine feed)	100 to 120	100 to 120	450	450	" " "
1035	75 to 90	90 to 120	250	250	" " "
X-1315	175 to 200	175 to 200	400 to 500	400 to 500	" " "
1050	60 to 80	100	200	200	" " "
2315	90 to 110	90 to 110	300	300	" " "
3150	50 to 60	70 to 90	200	200	" " "
4340	40 to 50	60 to 70	200	200	Sulfurized and mineral oils
Stainless steel	100 to 120	100 to 120	240 to 300	240 to 300	" " "

1-1. The nose of the spindle projects out of the __________.	1-1. COLUMN Ref: 1.04
1-2. The saddle supports the __________.	1-2. WORK TABLE Ref: 1.07
1-3. The direction of spindle rotation is governed by the __________.	1-3. DIRECTIONAL CONTROL LEVER Ref: 1.11
1-4. A vertical milling attachment is mounted on the spindle nose and bolted to the __________.	1-4. COLUMN Ref: 1.13, Fig. 1-2
1-5. The purpose of a vertical milling attachment is to change the spindle rotation from horizontal to __________.	1-5. VERTICAL Ref: 1.14
1-6. Spindle speed is always expressed in __________.	1-6. RPM Ref: 1.23
1-7. The rate at which a cutter tooth passes over the workpiece surface is called the __________.	1-7. CUTTER SPEED Ref: 1.24
1-8. When you use published tables to set cutter speeds, should you start with the higher or lower cutter speed.	1-8. LOWER Ref: 1.29

Milling Feed Selection

1.30 In any milling operation, the workpiece is held stationary on the table while the table is advanced toward a rotating cutter. The speed at which the table moves the workpiece past the cutter is called the machine-table feed rate. The machine-table feed rate is expressed in inches per minute.

1.31 In order to determine the machine-table feed rate for a job, you must take several variables into consideration. These variables are:

- the spindle speed
- the chip feed—that is, the chip size that each cutter tooth can handle without breaking
- the number of cutter teeth.

1.32 Chip feed is expressed in inches per tooth. Table 1-2 shows the chip feed rates in inches per tooth for various types of workpiece materials when cutters made of high-speed steel are used. Published tables are also available showing chip feed rates in inches per tooth for harder cutter materials, such as carbide. By using such tables and the following formula, you can compute a machine-table feed rate for any workpiece material.

1.33 As in the previous example, assume that you are to face mill cast iron (medium). You are using a 12-tooth cutter made of high-speed steel. The spindle speed you computed earlier is 50 rpm. Referring to Table 1-2, you see that the chip feed for a face mill is 0.013 inch per tooth. You find the machine-table feed rate by using the following formula:

$$\text{MTFR} = \text{in./t} \times \text{T} \times \text{rpm}$$

where MTFR is the machine-table feed rate

in./t is the chip feed expressed in inches per tooth

T is the number of teeth on the cutter

rpm is the spindle speed.

In this case:

$$\text{MTFR} = 0.013 \times 12 \times 50$$

$$= 7.8 \text{ in./min}$$

Table 1-2. Suggested feed per tooth for high-speed steel milling cutters

Material	Face mills	Helical mills	Slotting and side mills	End mills	Form relieved cutters	Circular saws
Plastics	0.013	0.010	0.008	0.007	0.004	0.003
Magnesium and alloys	0.022	0.018	0.013	0.011	0.007	0.005
Aluminum and alloys	0.022	0.018	0.013	0.011	0.007	0.005
Free cutting brasses and bronzes	0.022	0.018	0.013	0.011	0.007	0.005
Medium brasses and bronzes	0.014	0.011	0.008	0.007	0.004	0.003
Hard brasses and bronzes	0.009	0.007	0.006	0.005	0.003	0.002
Copper	0.012	0.010	0.007	0.006	0.004	0.003
Cast iron, soft (150 to 180 B.H.)	0.016	0.013	0.009	0.008	0.005	0.004
Cast iron, medium (180 to 220 B.H.)	0.013	0.010	0.007	0.007	0.004	0.003
Cast iron, hard (220 to 300 B.H.)	0.011	0.008	0.006	0.006	0.003	0.003
Malleable iron	0.012	0.010	0.007	0.006	0.004	0.003
Cast steel	0.012	0.010	0.007	0.006	0.004	0.003
Low carbon steel, free machining	0.012	0.010	0.007	0.006	0.004	0.003
Low carbon steel	0.010	0.008	0.006	0.005	0.003	0.003
Medium carbon steel	0.010	0.008	0.006	0.005	0.003	0.003
Alloy steel, annealed (180 to 220 B.H.)	0.008	0.007	0.005	0.004	0.003	0.002
Alloy steel, tough (220 to 300 B.H.)	0.006	0.005	0.004	0.003	0.002	0.002
Alloy steel, hard (300 to 400 B.H.)	0.004	0.003	0.003	0.002	0.002	0.001
Stainless steels, free machining	0.010	0.008	0.006	0.005	0.003	0.002
Stainless steels	0.006	0.005	0.004	0.003	0.002	0.002
Monel metals	0.008	0.007	0.005	0.004	0.003	0.002

1.34 When milling scaly or abrasive materials, or when taking heavy cuts in larger workpieces, you can increase the machine-table feed rate if the spindle speed is reduced. If the cutter begins to form long, continuous chips, reduce the feed.

Depth of Cut

1.35 A milling cutter's depth of cut depends on the workpiece material, the proposed speed and feed, and the size of the cutter, but it should not be less than 0.015 in. You can produce a better surface finish by taking a roughing cut followed by a finishing cut.

Lubricants and Coolants

1.36 As a workpiece moves past a rotating cutter, the cutter goes through a cycle of heating up and cooling off. Heat is generated at the cutter tooth as it removes a chip. When the tooth leaves the workpiece material it has a chance to cool slightly before it goes back through the work.

1.37 Coolants and lubricants used in milling operations are generally the same as those used for other machining operations. Some metals, such as cast iron and brass, can be milled without using a lubricant.

1.38 Coolant and lubricant suppliers provide complete charts and tables to assist you in selecting the correct compound for any milling job. Clean out the reservoir on the milling machine and be sure that the filters are functioning properly. Be sure that flow lines for fluid are clear and that the lubricant reaches the work area without clogging.

Mounting the Workpiece

1.39 Milling machine tables are equipped with T-slots for clamps, straps, and other holding devices. The selection of fixtures for a job depends largely on workpiece size and shape and the milling operations to be performed.

1.40 Carefully analyze your project before deciding on a holding method for the workpiece. Make a list of the milling operations and the sequence in which they will be performed. Select a work mounting method that will permit you to perform as many operations as possible without moving the workpiece. This reduces the chances of error in realigning the work.

Using V-Blocks

1.41 Many jobs in the maintenance machine shop involve milling keyways and slots in cylindrical workpieces. An effective method for holding a cylindrical workpiece is to mount it in a V-block. Clamps installed on the top of the workpiece hold it in the V-block.

1.42 Many maintenance machine shops have V-blocks with keys in their bases. The key fits into the T-slot on the milling machine table. This makes alignment of the V-block on the table both easy and convenient (Fig. 1-3). If your shop does not have a keyed

Fig. 1-3. Using the V-block with key

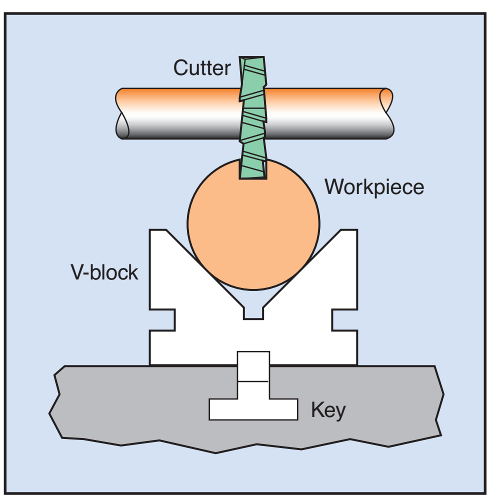


Fig. 1-4. Aligning V-block without a key

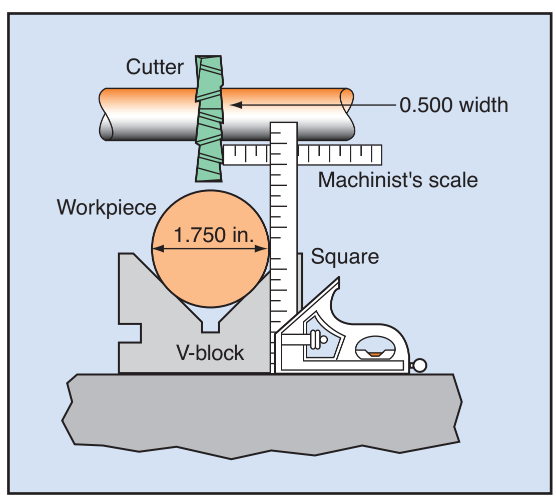


Fig. 1-5. Milling machine vise with a swivel base

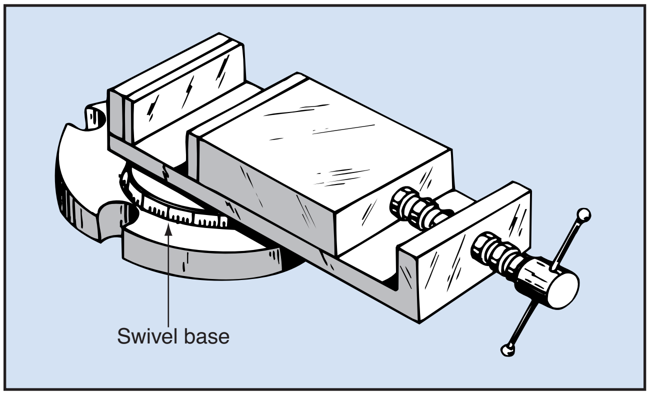


Fig. 1-6. Aligning the vise

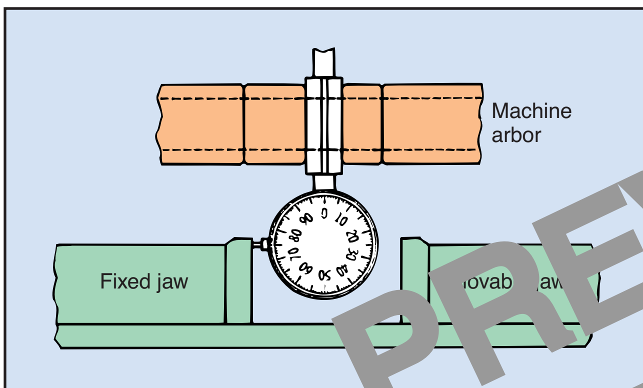
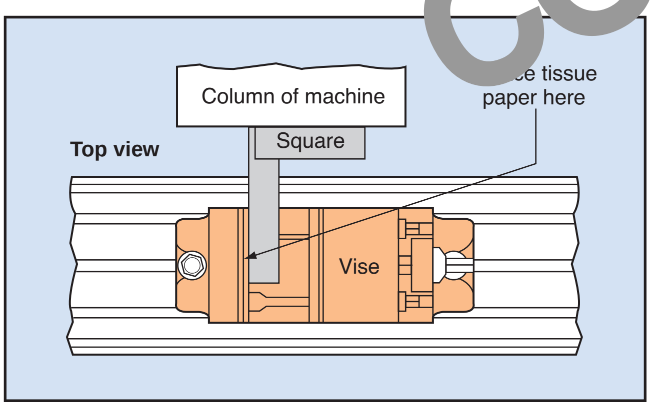


Fig. 1-7. Right-angle alignment of vise



V-block, the workpiece must be aligned under the cutter by using a square and a machinist's scale (Fig. 1-4 on the previous page).

1.43 Hold the square against the side of the workpiece and measure the distance from the side of the square blade to the side of the cutter. Manually adjust the cross feed until the scale's reading equals one-half the value obtained when you subtract the cutter width from the workpiece diameter.

1.44 For example, assume that the cutter width in Fig. 1-4 is 0.500 in. The workpiece diameter is 1.750 in. The cutter width (0.500) subtracted from the workpiece diameter (1.750) equals 1.250. One-half of this amount equals 0.625. You will have the cutter centered over the workpiece axis when the scale reads 0.625 in.

The Milling Machine Vise

1.45 The milling machine vise is one of the simplest and easiest fixtures to set up. Figure 1-5 shows a milling machine vise with a swivel base. In it, a workpiece can be held parallel to the length of the table or turned at an angle.

1.46 The angular graduations on the base of the vise allow you to align the workpiece accurately at any angle to the overhead cutter. Milling machine vises are made in many sizes.

Aligning the Vise on the Table

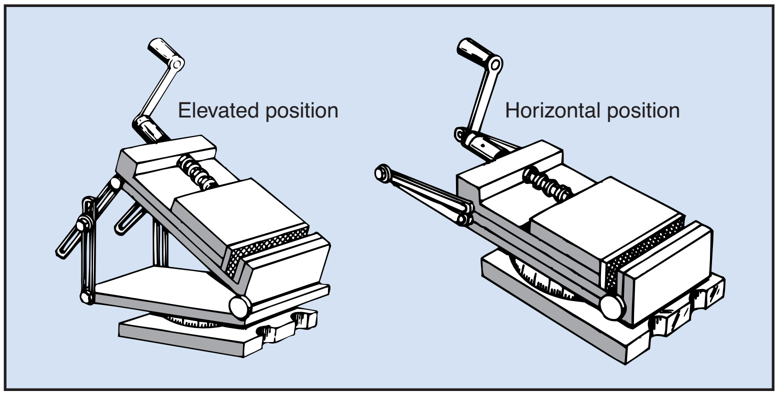
1.47 Clean the base and jaws of the vise thoroughly. Be sure the tightening screw is clean and free to move the live vise jaw to its full travel distance.

1.48 Check the table to be sure it is parallel with the face of the machine column. To do this, place a wide parallel bar between the face of the column and the inside edge of the table.

1.49 Use the cross-feed handwheel to move the table in toward the column face. When the parallel bar lightly contacts both the column face and the edge of the table, check for light between the bar and these surfaces. If no light shows, the table is parallel with the column face. Lock the table swivel in this position. If you want more accuracy, use a dial indicator.

1.50 Place the vise on the machine table in the approximate position for the job. Use a dial indicator to align the vise jaws so they are parallel with the length of the table (Fig. 1-6). Mount the indicator on the arbor. Use the cross-feed handwheel to move the vise until the indicator contacts the fixed jaw of the

Fig. 1-8. Universal vise



vise. Never use the movable vise jaw for reference during alignment. Tighten the vise hold-down bolts lightly, and set the dial indicator to zero.

1.51 Use the manual table feed to run the indicator point the whole length of the fixed jaw and observe the readings. Keep adjusting the vise on the table until the indicator reading remains constant along the entire length of the jaw. Lock the vise in this position on the table.

1.52 If the vise is aligned with its jaws at right angles to the table length, a machinist's square is used for alignment (Fig. 1-7). Place the stock of the square against the face of the milling machine column. Move the blade of the square into contact with the fixed jaw of the vise. Insert tissue paper between the jaw and the square blade. Adjust the vise on the table until you feel resistance when you try to pull the tissue paper out. Remove the paper and tighten the vise in position.

1.53 Milling machine vises are also made so they can tilt upward from the horizontal position. This type of vise is called a universal vise (Fig. 1-8). This ability to tilt upward is very useful if you must mill angle profiles on work.

Installing Work in a Vise

1.54 The workpiece shown in Fig. 1-9A is a special work-holding fixture. Suppose that you must make this fixture to fill a production requirement, because a standard fixture will not suit the production application. When the workpiece arrives at your milling machine, it is in a semifinished form with the dimensions as shown in Fig. 1-9B.

1.55 Select a milling machine vise that has a jaw capacity of at least 6 1/2 in. Align the vise on the milling machine table with its centerline as close as possible to the centerline of the table. If your shop does not have a vise that is long enough to accommo-

Fig. 1-9. Special work-holding fixture

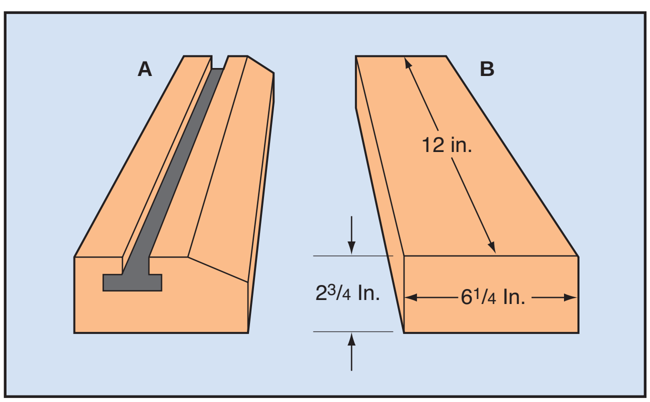
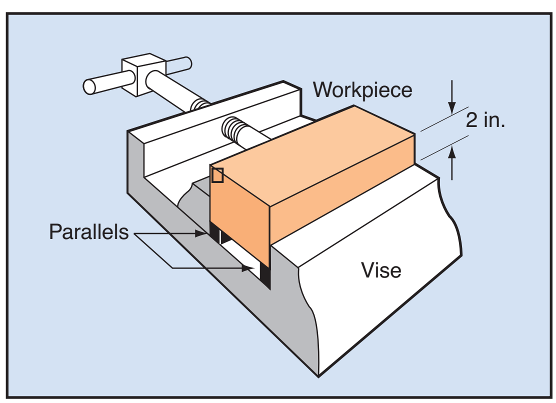


Fig. 1-10. Using parallels to elevate workpiece



date the 12 in. workpiece length, you can use two vises in exact alignment on the table.

1.56 Install two parallels that are at least 12 in. long in the vise. The parallels should be high enough to allow 2 in. of the workpiece to project above the top of the vise (Fig. 1-10 on the previous page). This provides cutter clearance for milling the angled surface on one side of the workpiece without having to disturb the vise setup later. Tighten the vise jaws securely.

1.57 Never strike the handle of a vise with a hammer. Striking the handle is unsafe and can damage the vise. Check the setup carefully. Be sure the workpiece does not rock in the vise. The vise and the workpiece should be like one piece firmly mounted on the milling machine table.

1.58 Use the manual controls to check the vertical, longitudinal, and crosswise movements of the table. The table should move smoothly and freely without jamming at any point. Be sure that the vise-mounted workpiece clears all structural parts of the milling machine. Make sure all setup tools are removed from the table and work area. The special work-holding fixture that is mounted in the vise at present is the workpiece you will mill in the next Lesson.

1-9. The speed at which the table moves the workpiece past the cutter is called the machine-table __________.	1-9. FEED RATE Ref: 1.30
1-10. Chip feed is expressed in inches per __________.	1-10. TOOTH Ref: 1.32
1-11. If a cutter is forming long, continuous chips, you should reduce the __________.	1-11. FEED Ref: 1.34
1-12. The less you must remount and realign work in milling, the less chance of __________.	1-12. ERROR Ref: 1.40
1-13. A key in the base of a V-block offers a convenient means of __________ the block.	1-13. ALIGNING Ref: 1.42
1-14. You can align a workpiece accurately at any angle with the cutter by using the __________ on the base of a vise.	1-14. ANGULAR GRADUATIONS Ref: 1.46, Fig. 1-5
1-15. To align the vise jaws requires the use of a(n) __________.	1-15. DIAL INDICATOR Ref: 1.50, Fig. 1-6
1-16. Striking the handle of a vise can damage it, and is also __________.	1-16. UNSAFE Ref: 1.57

Answer the following questions by marking an "X" in the box next to the best answer.

1-1. A universal horizontal milling machine's saddle swivel allows the table to move past the cutter

- ☐ a. at different angles
- ☐ b. with greater accuracy
- ☐ c. at a faster rate
- ☐ d. all of the above

1-2. A vertical milling attachment's spindle can be positioned at

- ☐ a. 90 degrees
- ☐ b. 45 degrees
- ☐ c. 15 degrees
- ☐ d. all of the above

1-3. Spindle speed is always expressed as the number of revolutions the spindle rotates in

- ☐ a. one second
- ☐ b. one minute
- ☐ c. two minutes
- ☐ d. one hour

1-4. Milling cutter speed is the speed at which a cutter tooth

- ☐ a. rotates in one revolution of the cutter
- ☐ b. turns in one revolution of the spindle
- ☐ c. passes over the surface of the workpiece
- ☐ d. cools after it makes a cut

1-5. Cutter speed is directly affected by

- ☐ a. size of the milling machine
- ☐ b. diameter of the cutter
- ☐ c. angle of feed
- ☐ d. position of the spindle

1-6. A machine-table feed rate is always expressed as

- ☐ a. rpm
- ☐ b. sfpm
- ☐ c. degrees
- ☐ d. inches per minute

1-7. Computing the machine-table feed rate correctly requires which of the following information?

- ☐ a. Spindle speed
- ☐ b. Number of cutter teeth
- ☐ c. Chip feed
- ☐ d. All of the above

1-8. When you are milling a workpiece, avoid taking a depth of cut less than ________ in.

- ☐ a. 0.150
- ☐ b. 1.50
- ☐ c. 0.015
- ☐ d. 0.5

1-9. A cylindrical workpiece is usually held on the milling machine table in a

- ☐ a. V-block
- ☐ b. vise
- ☐ c. collet
- ☐ d. clamp and strap

1-10. A workpiece mounted in a milling machine vise can be turned at an angle through the use of the

- ☐ a. fixed jaw
- ☐ b. screw
- ☐ c. collar
- ☐ d. swivel base

SUMMARY

The milling encountered in the maintenance machine shop can be done on a universal horizontal milling machine. The only difference between a plain horizontal milling machine and a universal horizontal milling machine is the table swivel on the universal. A horizontal spindle can easily be converted for vertical work by using a vertical milling attachment.

Before milling can be performed, you must compute both the spindle speed and the machine-table feed rate. You can compute these speeds and feeds by using two different formulas. The values used in these two formulas depend on variables such as workpiece material, cutter material, size of cutter, and the specific milling job at hand.

The two most basic devices for holding a workpiece on a milling machine table are the V-block and the swivel vise. Both of the devices may be clamped, strapped, or bolted to the table. Various risers, blocks, and parallels can be used for aligning and positioning the workpiece.

Answers to Self-Check Quiz

1-1. a. At different angles. Ref: 1.02

1-2. d. All of the above. Ref: 1.15

1-3. b. One minute. Ref: 1.23

1-4. c. Passes over the surface of the work piece. Ref: 1.24

1-5. b. Diameter of the cutter. Ref: 1.24

1-6. d. Inches per minute. Ref: 1.30

1-7. d. All of the above. Ref: 1.31

1-8. c. 0.015. Ref: 1.35

1-9. a. V-block. Ref: 1.41

1-10. d. Swivel base. Ref: 1.45, Fig. 1-5

Contributions from the following sources are appreciated:

Figure 1-1. Cincinnati Milacron
Figure 1-2. Cincinnati Milacron